A STUDY OF ANTHROPOMETRIC MEASUREMENTS AND ESTIMATION OF BODY MUSCLE MASS IN PRE-SCHOOL CHILDREN

THESIS
FOR
DOCTOR OF MEDICINE
(PAEDIATRICS)





BUNDELKHAND UNIVERSITY,
JHANSI (U. P.)

28274

1984

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This is to certify that the work on "A STUDY OF ANTHROPOMETRIC MEASUREMENTS AND ESTIMATION OF BODY MUSCLE MASS IN PRE-SCHOOL CHILDREN" which is being submitted for M.D.(Paediatrics) thesis by ANAND KUMAR AGARWAL has been carried out under my guidance and supervision in the department of Paediatrics. The techniques embodied in the thesis were undertaken by the candidate himself and the observations recorded have been periodically checked by me.

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ACKNOWLEDGEMENTS

It is with an overwhelming sense of gratitude that I wish to express my thanks to Dr.(Mrs.) S. Longia, M.D., Reader in the department of Paediatrics, M.L.B. Medical College, Jhansi, under whose able guidance, supervision and immense help, I had the opportunity to carry out this work. She had always been available with ready invaluable suggestions and unending encouragement. Her inspiration fostered me greatly throughout the study and it may not be an exaggeration to say that she is instrumental in the successful completion of the present work.

Words fail to express my deepest sense of gratitude to Prof. Ramesh Kumar, M.D., D.C.H., Head of the department of Paediatrics, M.L.B. Medical College, Jhansi for his constant attention and constructive criticism from time to time which have gone long way towards the successful completion of this study.

I wish to express sincere gratefulness to my revered teacher, Dr. L.D. Joshi, Ph.D., Reader in the department of Biochemistry, M.L.B. Medical College, Jhansi for his excellent guidance and supervision.

He not only boosted my morale showing his personal interest but also went beyond his field to suggest and correct me.

I am highly thankful to Mr. B.D. Mathur, M.Sc., D.M.S., Lecturer (Statistics) in the department of Obstetrics and Gynaecology, M.L.B. Medical College, Jhansi for able guidance, valuable advice and constant encouragement.

I feel highly obliged to Dr. A. Kaushik, M.D., Lecturer in the department of Paediatrics, M.L.B.Medical College, Jhansi for his expert guidance, valuable advice and unstinting help at every juncture.

I am highly grateful to Dr. R.S. Sethi, M.D., D.C.H., Lecturer in the department of Paediatrics, M.L.B. Medical College, Jhansi who was one of my most sincere helpers fulfilling all my needs and curiosities.

I take this opportunity to express my thanks to my colleagues and friends for rendering invaluable help and co-operation that I was constantly in need of.

I am undoubtedly thankful to Mr. K.M. Thomas, who has industriously worked for typing this volume of work. His great capacity and cheerfulness are two gifts which are essential in such work.

I bow in reverence to the little children and their parents, without whose co-operation this study could not be made a success. I shall remain thankful for ever.

Lastly, I am indebted to my honourable parents and brother, for their understanding and help throughout the period of study.

(ANAND KUMAR AGARWAL)

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"Science without religion is lame,
religion without science is blind."

—Albert Einstein

INTRODUCTION

INTRODUCTION

Health is the condition of perfect equilibrium and perfect harmony. It's final goal can only be achieved when there is a balanced growth of the body at each level. The term, 'growth' generally refers to a process by which fertilised ovum attains the adult status. "It is probable, that the essential process of growth proceed in all animals, whatever their form and size, according to a definite plan recognisable in the chemical constitution of the organism at any given stage in its life history (Forbes, 1952)".

After the International Year of the Child, expertise planning and programming of health services for young children has increased with the greater acumen in the content of different national programmes. Definitely these children are a high-risk group and their tragic situation calls for special efforts to recognise their exact level of health and their health related needs. Out of India's total population of 683.8 millions, 95 millions are young children aged 1-6 years.

To assess the pattern of growth in the paediatric age-group - clinical assessment, biochemical assessment and physical anthropometry, are in daily use for the last several decades, but out of them physical anthropometry has been the most common, simple, practical and valid parameter. It reflects the pattern of external growth and physical state of a child and also indicates, how the child deviates from the average at various ages in body size, build and nutritional status.

As the growth is cellular in nature, therefore, apart from anthropometric measurements, the study of cellular growth definitely gives a better reflection of growth process. The major tissue of the body, namely muscle, can be called as one functionating unit, as it reflects to some extent the dimensions of cellular growth in other tissues. Muscle is an easily accessible tissue and the study of increase in nuclear and fibre size represents an informative approach to the study of human growth.

The direct estimation of body muscle mass though more accurate, is an impracticable procedure. Ninety eight percent of total body creatine is present in the muscles. Creatinine, an end product of creatine metabolism appears in urine as a waste product and,

therefore, total body muscle mass can indirectly be calculated by estimating the 24 hrs. excretion of creatinine in urine. In view of these facts this study is designed to estimate total body muscle mass by 24 hrs urinary creatinine excretion and to know the relationship between various anthropometric measurements and total body muscle mass in pre-school children.

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REVIEW OF LITERATURE

REVIEW OF LITERATURE

One of the great mysteries of life is the power of growth, that harmonious development of composite organs and tissues from simple protoplasmic cells, with the ultimate formation of a complex organism with its orderly adjustment of structure and function (Chittenden, 1907).

Child development includes two types of growth, the one being visible, the other invisible.

'Visible growth' is a common place synonym for anatomic ontogenesis, which encompasses all of the structural modifications that a biologic organism undergoes during ontogeny. It includes the gamut of changes sometimes subgrouped under such captions as morphologic differentiation, dimensional growth, proportional development and structural maturation (Meredith, 1957).

Chemical and physiologic growth, on the other hand, is described as 'invisible growth', since it results from a sequence of biochemical and physiologic adjustments involving integrated chemical, metabolic and functional reactions by which the incorporation of

nutrients as new tissues or as renewal of the body, may take place. Invisible growth, therefore, is concerned with the subtler chemical, metabolic and physiologic functions and adaptations of the enlarging organs and tissues and fundamental changes in the body structure and compositions - it is the bulwork of physical growth. Visible and invisible growth coexist - neither can exist in isolation.

The basal metabolism is consistent with normal cell life in an individual at complete muscular rest, without nutrirature and surrounded by 30°C or more temperature (Palmer et al, 1914).

Lewis et al (1937) firstly established the precise relationship of body build to the basal metabolism in children aged two to twelve years.

CREATININE EXCRETION AND GROWTH :

'Kreatinine', a Greek word, literally means 'flesh'. In contradiction to the earlier workers who suggested that creatinine was present in the urine of infants only in fever or when meat extract was added to their diet, its direct relationship to active protoplasmic mass of body was firstly postulated by Folin (1905).

Furuto (1908) had shown that creatinine was present always in the urine of infants, and that the amount under normal and pathologic condition did not vary

greatly. Further evidence of the excretion of creatinine by infants was presented by many workers (Amberg and Rountree, 1910; Sedgwick, 1910; Rose, 1911).

Bloch and Schoenheimer (1939) by their isotopic study proved the fact that "creatinine simply represents a waste product of creatine metabolism in muscle".

Creatinine synthesis involves the amino acid glycine, arginine and methionine (as S- adenosylmethionine) and forms a reservoir of high-energy phosphate, namely Creatine phosphate which is readily convertible to ATP in muscles and other tissues.

Borsook and Dubnoff (1947) reported the following reactions in aqueous solution at 38°C -

(a) Phosphocreatine → creatinine + inorganic phosphate
(b) Phosphocreatine → Creatine + inorganic phosphate
(c) Creatine → Creatinine.

They were first order reactions and proceed independently of each other. The values of rate constants at 38°C over the pH ranging 6.0 to 7.5 were studied. The combined rate constants of reactions (a) and (c) were sufficient, without postulating the intervention of an enzyme, to correlate quantitatively the reported concentrations of phosphocreatine in muscle and the rate of formation of creatinine in autolyzing muscle. They

concluded that 98 per cent of total body creatine was located in the skeletal muscle and remaining 2 per cent was converted daily to creatinine and appeared in urine.

Kumar et al (1959), while experimenting on the six male and six female litters rats, found an increase in endogenous creatinine excretion with the size of "fat free mass".

ESTIMATION OF TOTAL BODY MUSCLE MASS

Scammon (1923), the German anatomist, firstly carried out the classic dissection studies and concluded that in infancy muscle weight was 25 per cent of the total body weight which increased to the adult level of 40 to 45 per cent at puberty.

Talbot (1938) calculated from the data available at that time that 1 gm of creatinine excreted in urine in 24 hrs was derived from 17.9 kg of muscle and this relationship was constant throughout the life period. By using the factor 17.9, the estimated total body muscle mass was of much lower percentage of body weight that expected on the basis of previous study (Scammon, 1923).

Cheek and co-workers (1957) did an exhaustive work to estimate the muscle mass by using the physiologic constituents of body. They found 97.8 ml intracellular water and 83 gms of muscle mass in 7 wks old male rat

weighing 220 gms. Sixty seven percent of this weight (63 gms) was intracellular water, it followed 56.9 per cent (55.68 ml), of total intracellular water was contained in muscle mass.

Same investigators (1965) assumed that muscle contained all the potassium of body while the bone not. They estimated the potassium from eviscerated rat without skin and also from the fresh sample of muscle and calculated the muscle mass as follows -

$$\text{Muscle mass} = \frac{\text{total carcass potassium}}{\text{concentration of potassium in fresh sample of muscle}}$$

Cheek et al (1965) also calculated the muscle mass by obtaining the weight of total non collagen protein and the dried solid muscle. The calculations were as follows -

$$\text{Muscle mass (gms.)} = \frac{\text{Total non collagen protein in carcass}}{\text{\% of dried solid in muscle}}$$

Same workers (1966) obtained the values of total body water (TBW), extracellular volume and of urinary creatinine, in 17 male and 19 female children and did a big calculation in following shape.

$$\text{Muscle mass (kg.) or Urinary creatinine (gms/day) x FACTOR} = \frac{\text{\% ICW in muscle x (TBW-ECV) litres}}{\text{Concentration of intracellular water in fat free fresh muscle (Litres/kg FFBM).}}$$

$$\text{FACTOR} = .569 \times \frac{\text{ICW (litres)}}{\text{Urinary creatinine (gm/day)} \times \text{muscle intracellular water (litres kg FFM)}}$$

In boys the value of factor was found 21.19 ± 3.51 and in girls that was 20.68 ± 4.05. The difference in values of factor was not statistically significant.

The statistical comparison (t-test of differences) between the factor obtained (21.2 and 20.7) and the assumed convenient value 20 did not reveal any significant difference, then they calculated the muscle mass as follows -

Muscle mass (kg.) = 24 hours creatinine excretion in grams × 20 (Cheek's factor)

RELATIONSHIP OF TOTAL BODY MUSCLE MASS

(1) WITH WEIGHT :

The pioneer worker Folin (1905) expressed that creatinine excretion had direct relationship to body weight.

Ambery and Morrill (1907) noticed low creatinine excretion per kg. of body weight in a child who was fat in comparison to a child who was under-weight for same age.

Shaffer (1908) coined the term 'creatinine coefficient' for milligrams of creatinine per kg body weight and found it to be 14.5 to 31.4 in normal men.

Wang et al (1926) reported the tendency of increasing creatinine excretion in children who were 10 per cent underweight after which a slight drop was observed. They concluded that a child who was not more than 15 per cent underweight, was simply deficient in the store of body fat and had as much active protoplasmic tissue as the normal child of his height would weigh and that he would be excreting the same amount of creatinine. His creatinine weight coefficient, therefore, would be higher.

Daniels and Hejinian (1929), while studying urinary excretion in 2 to 8 months old infants found creatinine coefficients to be 10.64, the lowest average and 12.98, the highest average. They further observed that the creatinine weight coefficient of all the infants studied were fairly comparable and were consistent for a given infant. Other investigators reported the same observations later on (Reynold et al, 1947; Clark et al, 1951).

Cheek et al (1968) found that 24 hrs urinary creatinine gave better idea of muscle mass than the creatinine coefficient.

Seth et al (1981) reported that muscle mass had significant correlation with body weight while studying the correlation and regression of cellular parameter.

(2) WITH AGE :

Hunter (1928) was the first to observe the variation in amount of creatinine excreted at different age periods. He found creatinine coefficient around 2.7 at birth, which rose to 5.5 to 8 with in first few months of life, 11 to 13 in third year and 13 to 19 in ninth year of life.

Scammon (1930) reported that the period of rapid growth in musculature was from birth to 6th year and from 12th to 16th years. Correspondingly, in period 5th or 6th to 11th or 12th years there was relatively little change in creatinine coefficient.

Marples and Levine (1942), while studying the infants aged from 3 weeks to 7 months found no difference in the creatinine excretion in this limited age group.

Clark (1951) examined more than 900 urine samples from healthy children aged 3 to 18 years for creatinine and found that creatinine excretion increased from 0.36 gm/24 hrs at 5 years to 1.58 gm/24 hrs at 17 years of age. The creatinine coefficient varied between 0.859 to 0.879 during four years of their study.

Stearns et al (1959) concluded that there was an increase in both, absolute and relative excretion of creatinine from birth to puberty.

Recently Seth et al (1981) reported a significant relationship between age and muscle mass, while studying the children of one to six years.

(3) WITH SEX :

Clark et al (1951) reported that the boys had high creatinine coefficient (25 ± 1) than the girls (21 ± 1) aged between 2 to 18 years.

Cheek et al (1968) on the other hand found creatinine coefficient 0.66 (SD ± 2.31 mg/kg/24 hrs) in boys and 0.71 (SD ± 2.04 mg/kg/24 hrs) in girls while studying infants and children and concluded that this difference was statistically insignificant.

(4) WITH LENGTH/HEIGHT :

Benidict and Mayers (1907) suggested that urinary creatinine had better relationship to length than the weight of the child.

Daniels and Hejinian (1929) originated a new ratio, named creatinine length coefficient. They expressed the creatinine length coefficient as milligram of creatinine excreted per centimeter of body length. It was found to be varying from 0.89 to 1.62 in infants which increased with increasing age. They maintained that creatinine excretion had better correlation with length rather weight of child.

Cheek et al (1968) showed in his 'Human growth' that in normal boys, aged between 5 and 16 years, the relationship was best expressed as a quadratic equation. When breaking line technique was applied, the break occurs at 137.5 cm.

Viteri and Alvarado (1970) devised a new ratio, the creatinine-height index (CHI) for estimating the relative muscle mass. They did not consider the age because height retardation usually occurred in developing areas. They got CHI close to 1.0 in normal children whose height were between 64.8 to 135 cm.

$$\text{CHI} = \frac{\text{24 hrs creatinine excretion of subject}}{\text{24 hrs creatinine excretion of normal child of same height.}}$$

Seth et al (1981) found significant correlation of height and muscle mass, while studying 16 male children in age group of 1 to 6 years.

(5) <u>WITH HEAD CIRCUMFERENCE AND MID-ARM CIRCUMFERENCE</u> :

Seth et al (1981) reported that the results of step-up regression showed that the best prediction of muscle mass was seen with height and mid-arm circumference taken together. Head circumference had no relationship with muscle mass.

TOTAL BODY MUSCLE MASS IN ABNORMAL CHILDREN

(A) IN MALNOURISHED CHILDREN :

Wang et al (1926) studied 26 normal and under-weight children. They observed that when a child was more than 15 per cent below average, he began to show signs of loss of active protoplasm in a lowered metabolism and hence, a lower creatinine coefficient. They suggested that it would be more appropriate to use 15 per cent under-weight for his age as the margin of undernourishment in children, rather than existing 10 per cent.

Standard et al (1959), studying on malnourished children, inferred the low creatinine excretion in these children which increased during rehabilitation. The 'muscle bulk' and 'fat bulk' were increased relatively more than body weight.

Arroyave et al (1961) studied 9 children of kwashiorkor. They found very low creatinine excretion initially which increased sharply during first week of treatment. The magnitude and rate of this increase was too great to be accounted for by a change in muscle mass.

Garrow et al (1965) carried out the post-mortem analysis of 5 malnourished and 4 relatively well nourished children of 6 months to 16 months age. They observed that in contrast to the finding in animal

experiments, the composition of fat free body of children showed wide variation, and it was not possible to predict accurately total protein in severely malnourished child from body weight, total water potassium, skinfold measurements or any combination of these measurements. They found total proteins to be severely reduced in malnourished children.

Picou et al (1965) examined the urine of ten malnourished infants for hydroxyproline and creatinine and found their values to be lower than the normal infants. Hydroxyproline and creatinine excretion were initially varied from 6.0 - 29.9 mg/24 hrs (mean 14.6) and 10.8 mg/kg/day / 0.9 mg/cm/day respectively which increased to 46.0 to 76.8 mg/24 hrs (mean 55.0) and 12.3 mg/kg/day / 1.4 mg/cm/day after 2 months of treatment. They suggested that rate of catabolism of collagen was found to be greatly reduced in malnourished infants.

Cheek et al (1970) did a biochemical analysis of muscle of nine malnourished peruvian infants (3 with kwashiorkor and 6 with marasmus) for DNA, RNA, protein, collagen, Mg, Zn, Cl and fat. Creatinine excretion was used as an index of muscle mass. After a big calculation they concluded that protein synthesis in muscle was compromised during malnutrition and loss of cell size accounted for most of the loss of muscle mass.

(B) IN CONGENITAL HEART DISEASE :

Cheek et al (1966) found that in general children of congenital heart disease exhibiting growth retardation had a reduction of muscle cell population for age. This reduction was not commensurate with linear growth so that such patients had less than normal muscle cell mass per unit height. They found that this phenomenon was more pronounced in girls. They concluded that cell size was also altered in cardiac patients - either they possessed enlarged muscle cells or small muscle cells.

(C) IN ENDOCRINAL DISORDERS :

Cheek et al (1966, 1968) reported that patients with hypopituitarism, acquired hypothyroidism, or primordial or genetic dwarfism had a reduction in cell number relative to age; whereas cretins appeared to have a normal cell number, but the patients with over-growth or precocious puberty had increased cell number for age. Regarding the cell size, pituitary dwarfs had smaller cells than one might expect relative to body size, and this situation was corrected by human growth hormone. Patients with acquired hypothyroidism had large cells for body size and the introduction of thyroid therapy caused a shrinkage of individual cell mass towards a normal or subnormal level. In both instances cell multiplication was active. Patients

given androgen therapy demonstrated an increase in cell size and cell number in the proposed study.

(D) IN CONGENITAL RUBELLA SYNDROME :

Cheek et al (1968) studied four patients of congenital rubella syndrome and found the reduction in muscle mass, creatinine excretion and in the number of muscle nuclei.

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MATERIAL AND METHODS

MATERIAL AND METHODS

Study sample consisted of 90 apparently normal children one to six years of age, who were admitted either for study or whose siblings were admitted for treatment in the department of Paediatrics, M.L.B. Medical College, Jhansi (U.P.). Besides recording the name, age, sex, geniological, dietetic, immunological, developmental and socio-economic history, each child was subjected to thorough physical and systemic examination.

ANTHROPOMETRIC MEASUREMENTS :

Weight :- Weight was recorded by using spring weighing machine, nearest to 0.25 kg. For those children who could not stand, infant weighing machine was used, capable of taking weight upto 10 kg to the nearest of 0.5 kg. Zero error if found, was corrected every time before weighing a child. Each child was weighed with minimum clothings on.

Length/Height :- Recumbant length (crown-heal length) was measured of children of 5 years or less than that by using an infantometer, nearest to 0.1 cm. The child's head was held firmly in contact with the fixed board on one end and the feet were kept at right angle to straight legs in contact with the sliding board on the other end.

A specially designed stadiometer was used to measure standing height of children above 5 years of age nearest to 0.1 cm. The child was allowed to stand on the platform without shoes and socks, heel touching each other and toes separated at an angle of 45°. The head was positioned as child looks straight and after a gentle compression of horizontal flat board, the reading was recorded.

Head circumference : The maximum circumference of head was measured in a steady child. The tape was placed firmly, anteriorly on frontal bone just superior to the supraorbital margin, above the ears laterally at same level and over maximum occipital protuberance posteriorly. It was placed sufficiently tense to crush the hairs against skull. The reading was taken on one side of skull.

Chest circumference : Using the same tape, the chest circumference was taken in mid-respiration at the level of xiphoid cartilage in a plane right angle to the vertebral column in a recumbent position upto 5 years of age and thereafter in standing position, nearest to 0.1 cm.

Mid-arm circumference : The mid-arm circumference of left upper arm was measured at a point midway between acromian process of scapula and olecranon process of ulna, while arm was hanging down freely. The tape was

gently but firmly placed around the arm and to avoid the error, the readings were taken against 10 cm. mark, nearest to 0.1 cm. Later 10 cm was deducted from the total reading.

Maximum-calf circumference : Similarly maximum left calf circumference was measured in standing position on the child.

Same weighing machines, instruments and flexible, non-strechable steel tape of half centimeter width, were used throughout one study period.

ESTIMATION OF 'TOTAL BODY MUSCLE MASS' :

Creatinine excretion was used as an index of total body muscle mass. Creatinine estimation was done in 24 hrs urine sample by alkaline picrate method (Bousnes and Taussky, 1945). Total body muscle mass was then calculated by the following equation suggested by Cheek (1968) -

$$\text{Total body muscle mass (in kilograms)} = \text{24 hrs creatinine excretion in grams} \times 20$$

Cheek's factor 20 was used since each gram of creatinine excretion appears to come from 20 kg of muscle mass.

COLLECTION OF URINE :

In male children 24 hrs urine sample was collected by using the finger stalks/condoms connected with a tube to a sterile bottle with all aseptic precautions.

In female children, it was only possible to collect the urine in older ons, who had achieved the bladder control. Child was asked to evacuate the bladder in a clean pot. The urine sample was finally transferred to a sterile collecting bottle through a funnel to avoid any spilling of the sample.

Each collecting bottle was marked in millilitres. The 24 hrs volume of urine was measured and recorded. Approximately 10 ml. of this urine sample was taken after a thorough shake, for creatinine estimation.

ESTIMATION OF CREATININE IN URINE :
(ALKALINE PICRATE METHOD) (Bonsnes and Taussky, 1945).

Before estimating the urinary creatinine each urine sample was specially examined for glucose and acetone, to rule out the possibility of interference, and if present, they were discarded from the study.

Principle : Estimation of creatinine makes use of the 'Jaffe' reaction - the production of red colour with an alkaline picrate solution (Clark and Thompson, 1949).

Reagents used :

1. Picric acid (0.04 N) - It was made by adding 9.16 grams of dry picric acid in 1 litre of distilled water. It was dried between two filter papers before weighing (Benedict, 1922, 1929).

2. Sodium hydroxide (0.75 N) - The solution was prepared by dissolving 30 gms of sodium hydroxide in 1 litre distilled water.

3. Stock solution of creatinine (1 mg/ml) - It was prepared by dissolving 1 mg of creatinine in 0.1 N hydrochloric acid and was made upto a litre with the acid. This solution contained 1 mg creatinine per ml.

4. Standard creatinine solution - It was prepared by diluting 1 ml. of stock solution to 100 ml with distilled water. It contained 0.01 mg of creatinine per ml.

Technique :

Five millilitres of urine was diluted with distilled water to 500 ml in a volumetric flask. Three millilitres of this diluted urine was pipetted into a test tube and 1 ml of 0.04 N picric acid solution followed by 1 ml of 0.75 N sodium hydroxide solution was added into it. Three millilitres (=0.03 mg) of standard creatinine solution for use and 3 ml of water

for blank was treated in the same way by adding 1 ml of 0.04 N picric acid solution followed by 1 ml of 0.75 N sodium hydroxide solution.

After 15 minutes, it was read in the colorimeter with green filter.

Calculations :

Since the standard creatinine solution contained 0.03 mg creatinine and 3 ml of diluted urine correspond to 0.03 ml of the original urine, the creatinine in urine was estimated by the following equation -

$$\text{Grams creatinine per litre of urine} = \frac{\text{Reading of unknown}}{\text{Reading of standard}} \times 0.03 \times \frac{1000}{0.03}$$

$$= \frac{\text{Reading of unknown}}{\text{Reading of standard.}}$$

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OBSERVATIONS

OBSERVATIONS

The present work consisted of 90 apparently normal children one to six years of age, who were admitted either for study purpose or whose siblings were admitted for treatment in the department of Paediatrics, M.L.B. Medical College, Jhansi (U.P.). Out of these 90 children, 68 were males and 22 were females (Table - I).

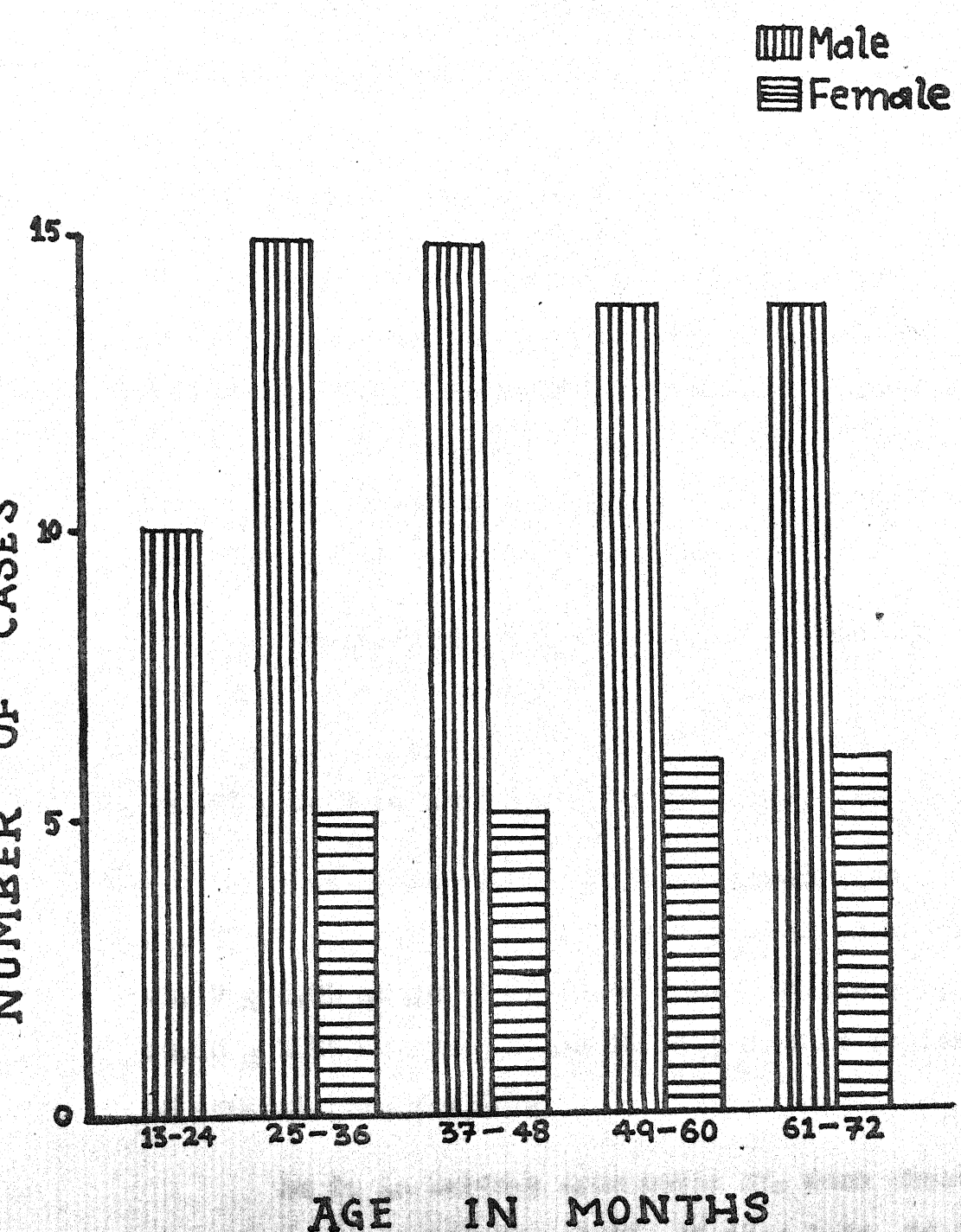
Table I

Age and sex distribution.

Groups	Age (months)	Male	Female
A	13 - 24	10	-
B	25 - 36	15	5
C	37 - 48	15	5
D	49 - 60	14	6
E	61 - 72	14	6
		68	22

(n=90)

BAR-DIAGRAM SHOWING
AGE AND SEX DISTRIBUTION



Children were divided according to their age in five different groups. In group A, children were of 13-24 months of age, while in group B, C, D and E children were of 25-36, 37-48, 49-60 and 61-72 months of age respectively. Group A consisted of only 10 male children, while group B, C, D and E consisted of 15, 15, 14 and 14 boys, and 5,5, 6 and 6 girls respectively (Table - I).

Table II depicts the mean (± S.D.) of various anthropometric measurements in different age-groups. The mean of body weight in kilograms was 8.85 ± 1.68 of group A, 9.92 ± 1.55 of group B, 12.06 ± 1.93 of group C, 13.02 ± 1.44 of group D and 16.15 ± 1.28 of group E children.

The children of different age groups had the mean (± S.D.) height/length 78.31 ± 4.71; 86.40 ± 6.61, 96.56 ± 6.39, 96.59 ± 5.62 and 107.03 ± 5.63 in centimeters respectively (Table II).

Head circumference in centimeters mean (± S.D.) was 44.59 ± 4.06 in children of group A, 45.77 ± 1.55 of group B, 45.46 ± 1.55 of group C, 46.86 ± 1.33 of group D and 47.80 ± 0.86 in children of group E (Table - II).

As it is evident from table II, mean chest circumference was 45.58 ± 3.32, 47.13 ± 1.71, 46.93 ± 2.48,

Table II

The anthropometric measurements in different age groups.

Groups	Weight (kg.) Mean ± S.D.	Height/length (cm.) Mean ± S.D.	H.C. (cm.) Mean ± S.D.	C.C. (cm.) Mean ± S.D.	M.A.C. (cm.) Mean ± S.D.	M.C.C.(cm.) Mean ± S.D.
A	8.85 ± 1.68	78.31 ± 4.71	44.59 ± 4.06	45.58 ± 3.32	12.60 ± 0.50	15.27 ± 1.31
B	9.92 ± 1.55	86.40 ± 6.61	45.77 ± 1.55	47.13 ± 1.71	13.67 ± 0.66	16.95 ± 0.70
C	12.06 ± 1.93	96.56 ± 6.39	45.46 ± 1.55	46.93 ± 2.48	14.23 ± 0.43	17.13 ± 0.74
D	13.02 ± 1.44	96.59 ± 5.62	46.86 ± 1.33	49.63 ± 2.23	14.53 ± 0.93	18.48 ± 1.19
E	16.15 ± 1.28	107.03 ± 5.63	47.80 ± 0.86	49.29 ± 1.18	14.97 ± 0.77	18.34 ± 0.99

H.C. - Head circumference.

C.C. - Chest circumference.

M.A.C. - Mid-arm circumference.

M.C.C. - Maximum-calf circumference.

49.63 ± 2.23 and 49.29 ± 1.18 in different age groups respectively.

Table XI also shows the mean (± S.D.) of mid-arm circumference in centimeters, it was 12.60 ± 0.50, 13.67 ± 0.66, 14.23 ± 0.43, 14.53 ± 0.93 and 14.97 ± 0.77 in divided groups of study sample respectively.

The mean (± S.D.) of maximum-calf circumference in centimeters is also shown in table XI, it was 15.27 ± 1.31 in group A, 16.95 ± 0.70 in group B, 17.13 ± 0.76 in group C, 18.48 ± 1.19 in group D and 18.34 ± 0.99 in group E children.

Table XII

24 hrs creatinine excretion in different age groups.

Groups	24 hrs creatinine excretion in urine (gms) Mean ± S.D.		
	Male (68)	Female (22)	Total (90)
A	0.13 ± 0.02	-	0.13 ± 0.02
B	0.18 ± 0.18*	0.14 ± 0.02*	0.17 ± 0.03
C	0.25 ± 0.04*	0.22 ± 0.05*	0.24 ± 0.04
D	0.24 ± 0.05‡	0.23 ± 0.04‡	0.24 ± 0.05
E	0.32 ± 0.05*	0.31 ± 0.02*	0.32 ± 0.04

* statistically not significant (P $\nearrow$ 0.05).

‡ statistically significant (P $\swarrow$ 0.01).

BAR-DIAGRAM SHOWING 24 hrs. CREATININE EXCRETION IN DIFFERENT AGE GROUPS

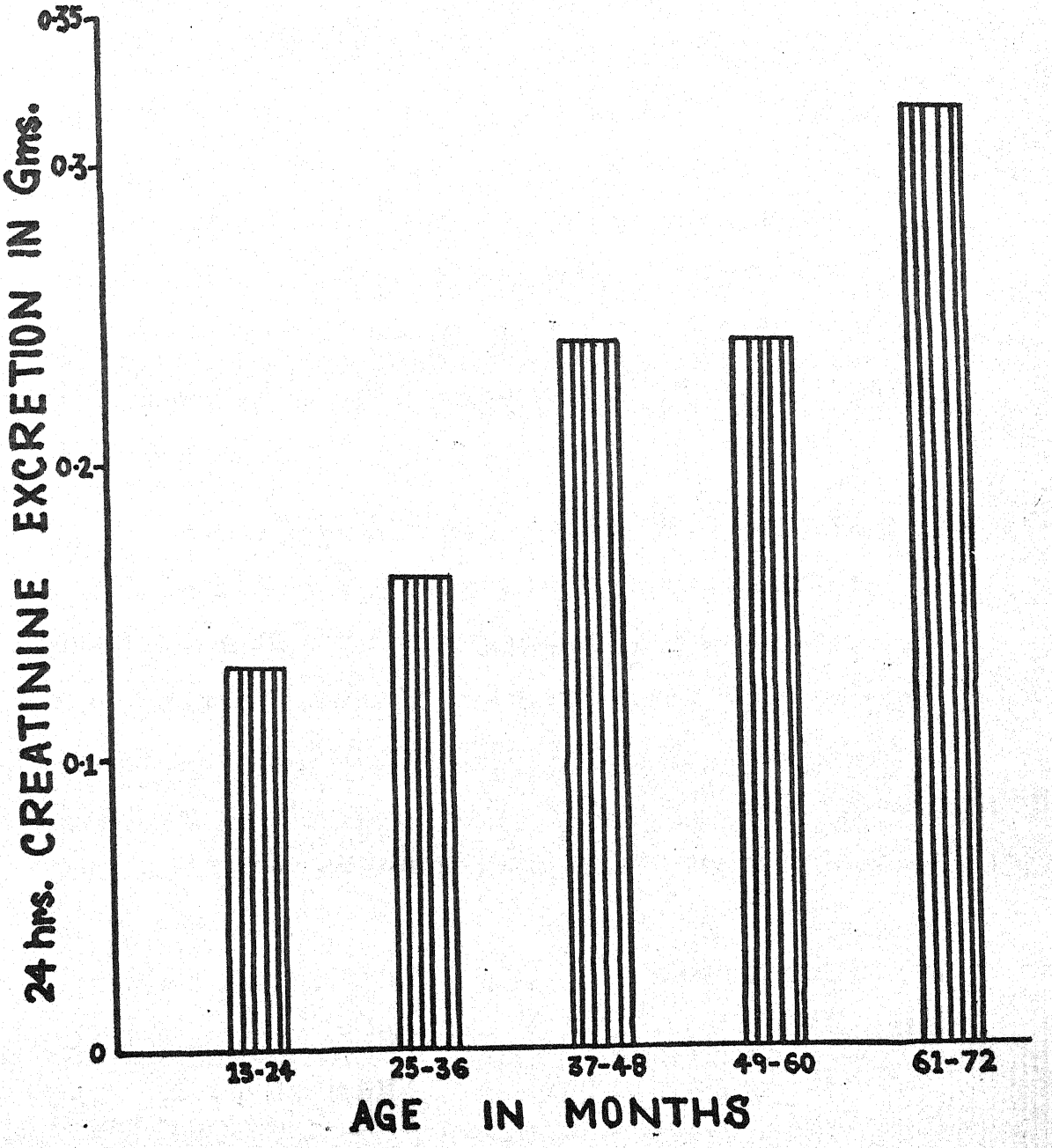


fig. 2.

Table XII shows the 24 hrs urinary creatinine excretion (grams) in male, female and in combined population of different age-groups. Boys had 0.13 ± 0.02, 0.18 ± 0.18, 0.25 ± 0.04, 0.24 ± 0.05 and 0.32 ± 0.05 creatinine excretion respectively. There was no girl in group A, while the girls of group B had 0.14 ± 0.02, group C 0.22 ± 0.05, group D 0.23 ± 0.04 and group E had 0.31 ± 0.02. In combined population of male and female it was 0.13 ± 0.02, 0.17 ± 0.03, 0.24 ± 0.04, 0.24 ± 0.05 and 0.32 ± 0.04 respectively in different age groups.

The values of creatinine weight coefficient and creatinine length/height coefficient of males, females and of combined population in different age groups are shown in table IV. Creatinine weight coefficient in male children was 14.68, 17.37, 20.00, 16.30 and 19.74 respectively in different age groups. Female children of group B had 16.27, group C 18.60, group D 21.30 and of group E children had 19.37 creatinine weight coefficient. In combined population the values were 14.68, 17.13, 19.90, 18.43 and 19.81 respectively in studied different age groups.

In male children the creatinine length/ height coefficient was 1.66 in group A, 2.03 in group B, 2.40 in group C, 2.20 in group D and 2.97

Table IV

Creatinine weight and length/height coefficients in different age-groups.

Group	Creatinine weight coefficient			Creatinine length/height coefficient		
	Male	Female	Total	Male	Female	Total
A (10)	14.68	-	14.68	1.66	-	1.66
B (20)	17.37	16.27	17.13	2.03	1.73	1.96
C (20)	20.00	18.60	19.90	2.40	2.32	2.46
D (20)	16.30	21.30	18.43	2.20	2.60	2.48
E (20)	19.74	19.37	19.81	2.97	2.92	2.98

BAR - DIAGRAM SHOWING

CREATININE WEIGHT COEFFICIENT IN POPULATION

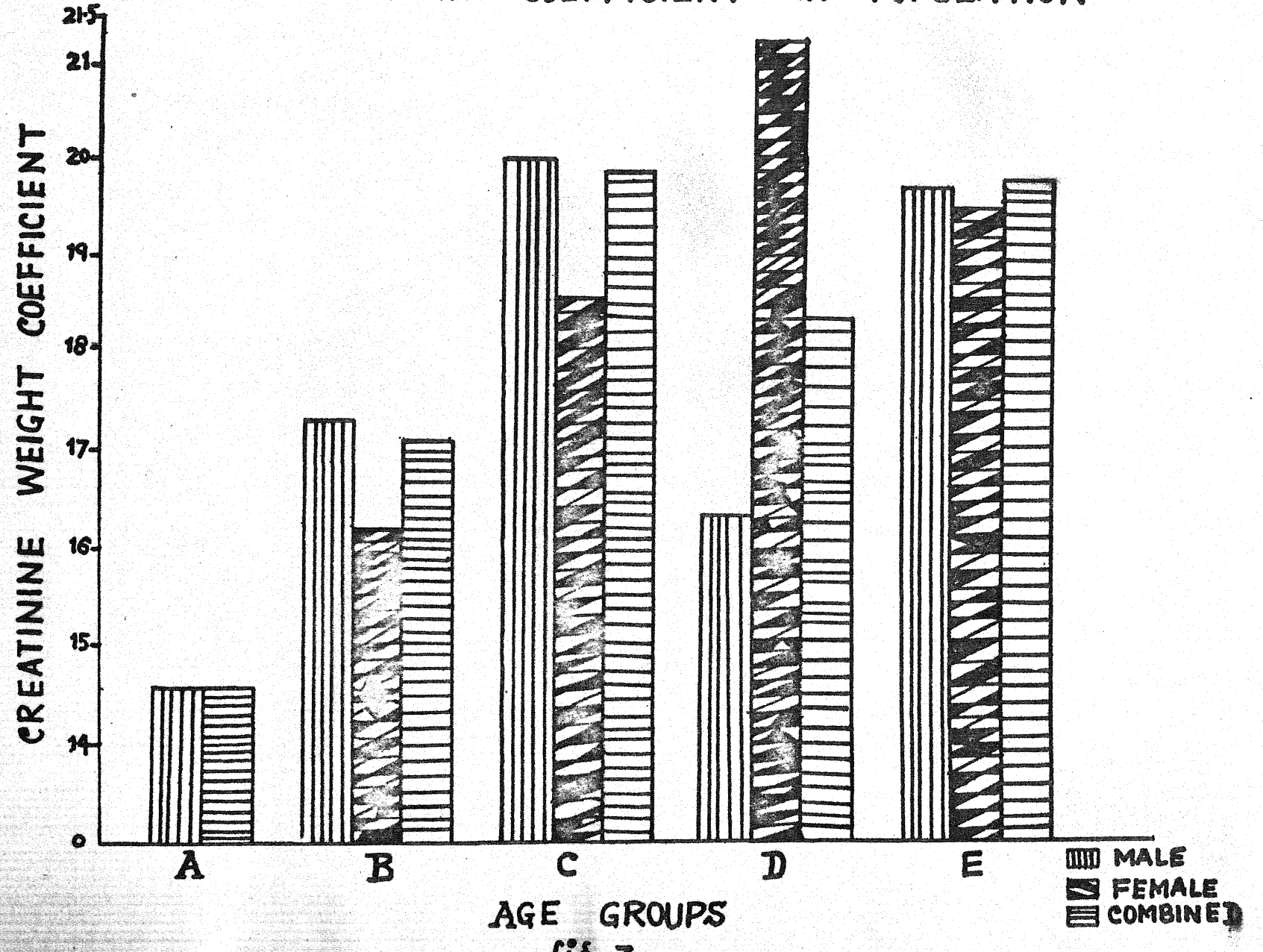


fig-3.

BAR-DIAGRAM SHOWING
CREATININE LENGTH/HEIGHT COEFFICIENT IN POPULATION

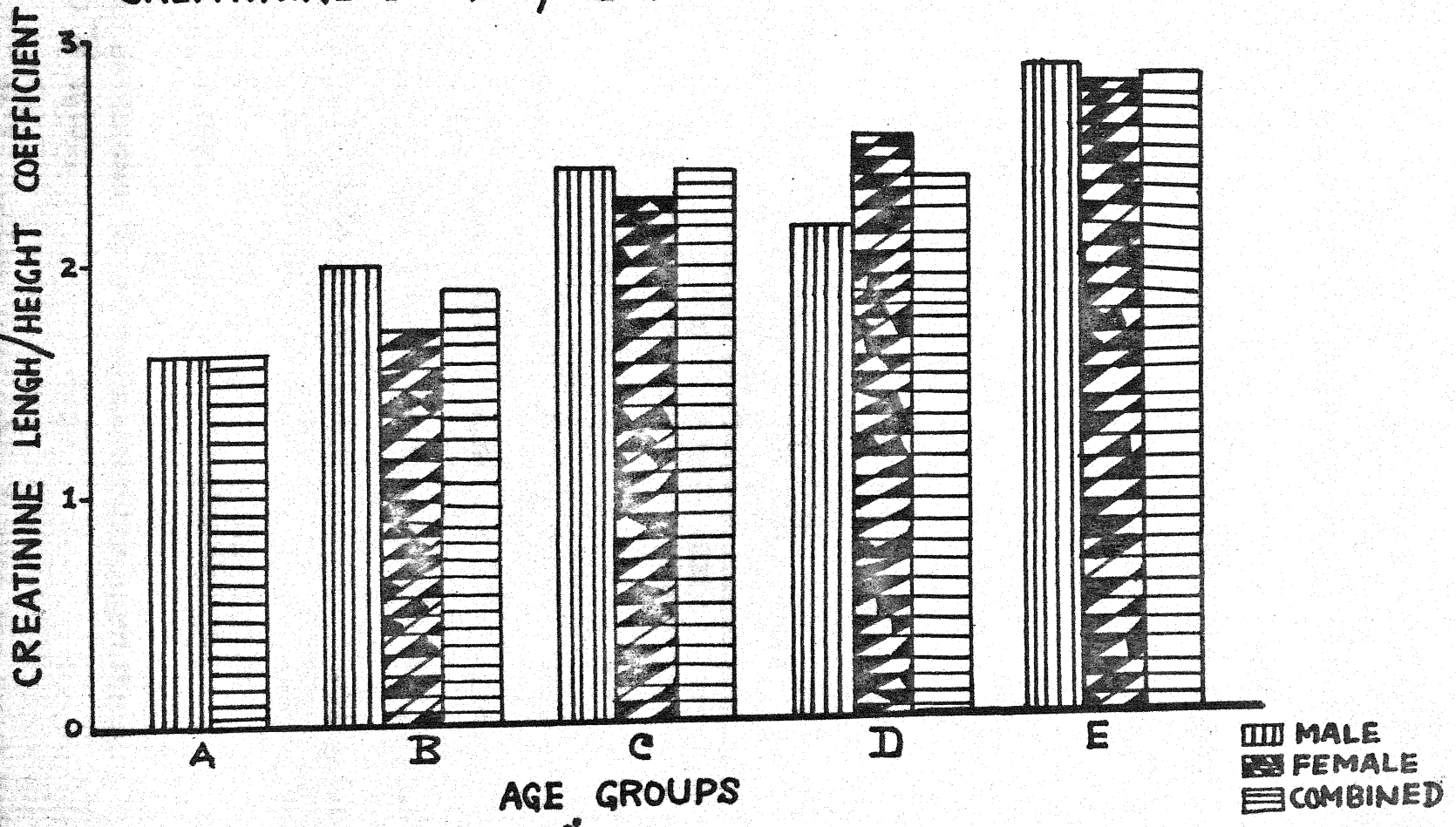


fig-4.

in group E. While the female children had 1.73 in group B, 2.32 in group C, 2.60 in group D and 2.92 in group E. On combining the male and female population creatinine length/height coefficient was 1.66, 1.96, 2.48, 2.48 and 2.98 respectively in different age groups.

Table V

Total body muscle mass in different age-groups.

Groups	Total body muscle mass (kgs.) Mean ± S.D.		
	Male (68)	Female (22)	Total (90)
A	2.73 ± 0.48	-	2.73 ± 0.48
B	3.78 ± 0.71*	2.98 ± 0.48*	3.58 ± 0.74
C	5.06 ± 0.80†	4.59 ± 1.06†	4.94 ± 0.87
D	4.99 ± 1.08†	4.71 ± 0.90†	4.91 ± 1.01
E	6.53 ± 1.05†	6.47 ± 0.15†	6.51 ± 0.87

* The difference is statistically significant ($P < 0.05$).

† The difference is not statistically significant ($P > 0.05$).

It is evident from table V that the total body muscle mass (kilograms) of boys in different age groups was 2.73 ± 0.48, 3.78 ± 0.71, 5.06 ± 0.80, 4.99 ± 1.08

BAR-DIAGRAM SHOWING RELATIONSHIP OF TOTAL BODY MUSCLE MASS WITH AGE

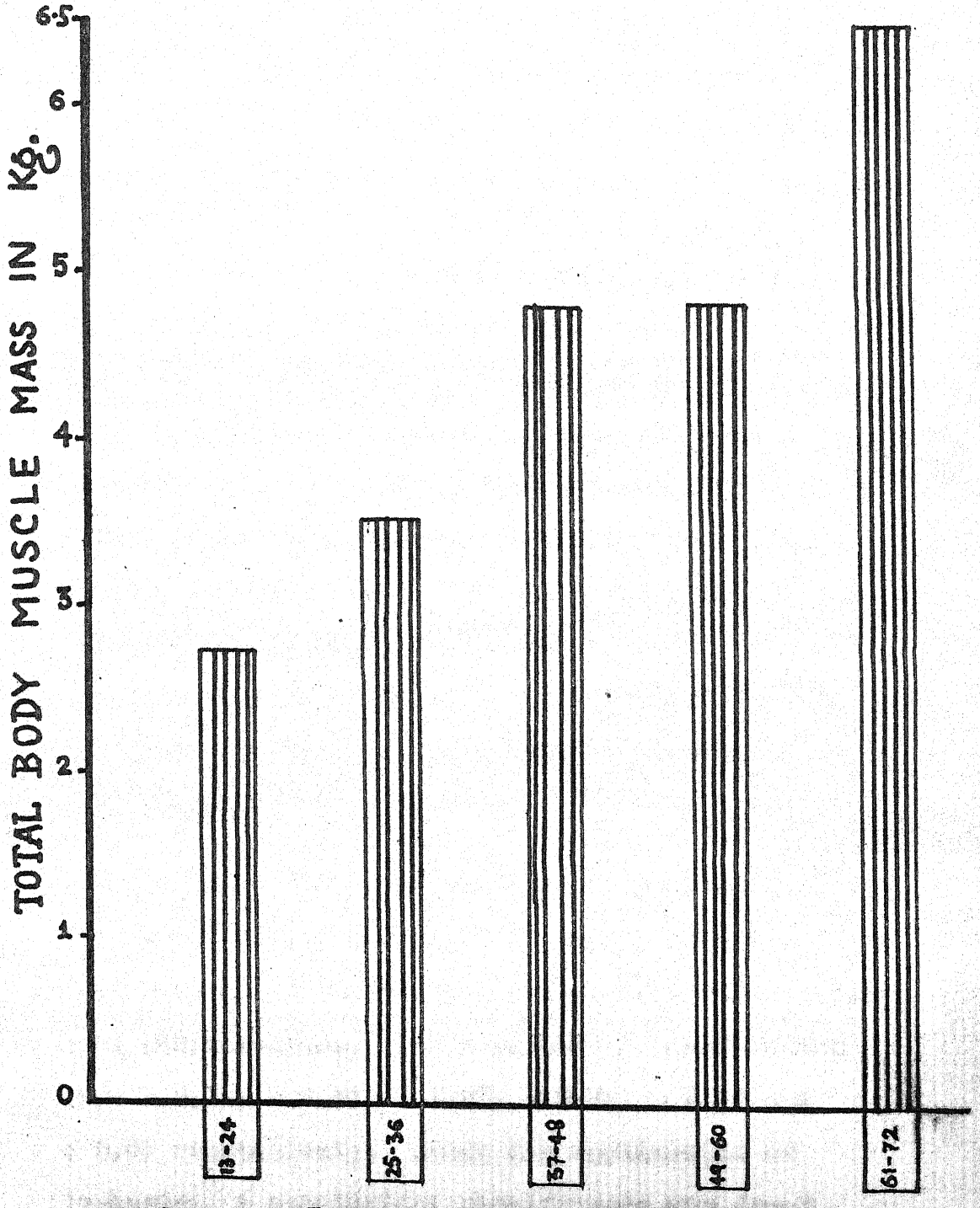


fig. 5.

and 6.53 ± 1.05 respectively. Group A consisted of no girl while the girls of group B had 2.98 ± 0.48, group C 4.59 ± 1.06, group D 4.71 ± 0.90 and group E had 6.47 ± 0.15 muscle mass. On combining the male and female population of different age-groups, the muscle mass was 2.73 ± 0.48, 3.58 ± 0.74, 4.94 ± 0.87, 4.91 ± 1.01 and 6.51 ± 0.87 respectively in kilograms.

Table VI reflects the correlation matrix of various growth parameters collectively in all children. The correlation coefficients of total body muscle mass to age, weight, height/length, head circumference, chest circumference, mid-arm circumference and maximum-calf circumference were + 0.76, + 0.89, + 0.97, + 0.50, + 0.17, + 0.82 and + 0.62 respectively. The 't-tests' revealed significant correlation of total body muscle mass to various growth parameters except to chest circumference.

Same table also depicts the correlation of mid-arm circumference to age, weight, height/length, maximum-calf circumference, chest circumference and head circumference. The correlation coefficients were + 0.70, + 0.69, + 0.82, + 0.74, + 0.48 and + 0.49 respectively. After the application of 't-tests', a statistical significance was found between mid-arm circumference and the above mentioned growth parameters.

Table VI

Correlation matrix of different growth parameters.

	Weight	Height	MCC	CC	HC	MAC	TBMM
Age	+ 0.76*	+ 0.82*	+ 0.65*	+ 0.50*	+ 0.18‡	+ 0.70*	+ 0.76*
Weight		+ 0.88*	+ 0.53*	+ 0.39*	+ 0.19‡	+ 0.69*	+ 0.89*
Height			+ 0.63*	+ 0.49*	+ 0.34*	+ 0.82*	+ 0.97*
MCC				+ 0.59*	+ 0.55*	+ 0.74*	+ 0.62*
CC					+ 0.37*	+ 0.48*	+ 0.17‡
HC						+ 0.49*	+ 0.50*
MAC							+ 0.82*

HC - Head circumference,
CC - Chest circumference,
MAC - Mid-arm circumference,
MCC - Maximum-calf circumference,
TBMM - Total body muscle mass.

‡ = Not significant,
* = Highly significant ($P < 0.001$)

GRAPH SHOWING RELATIONSHIP OF TOTAL BODY MUSCLE MASS AND WEIGHT

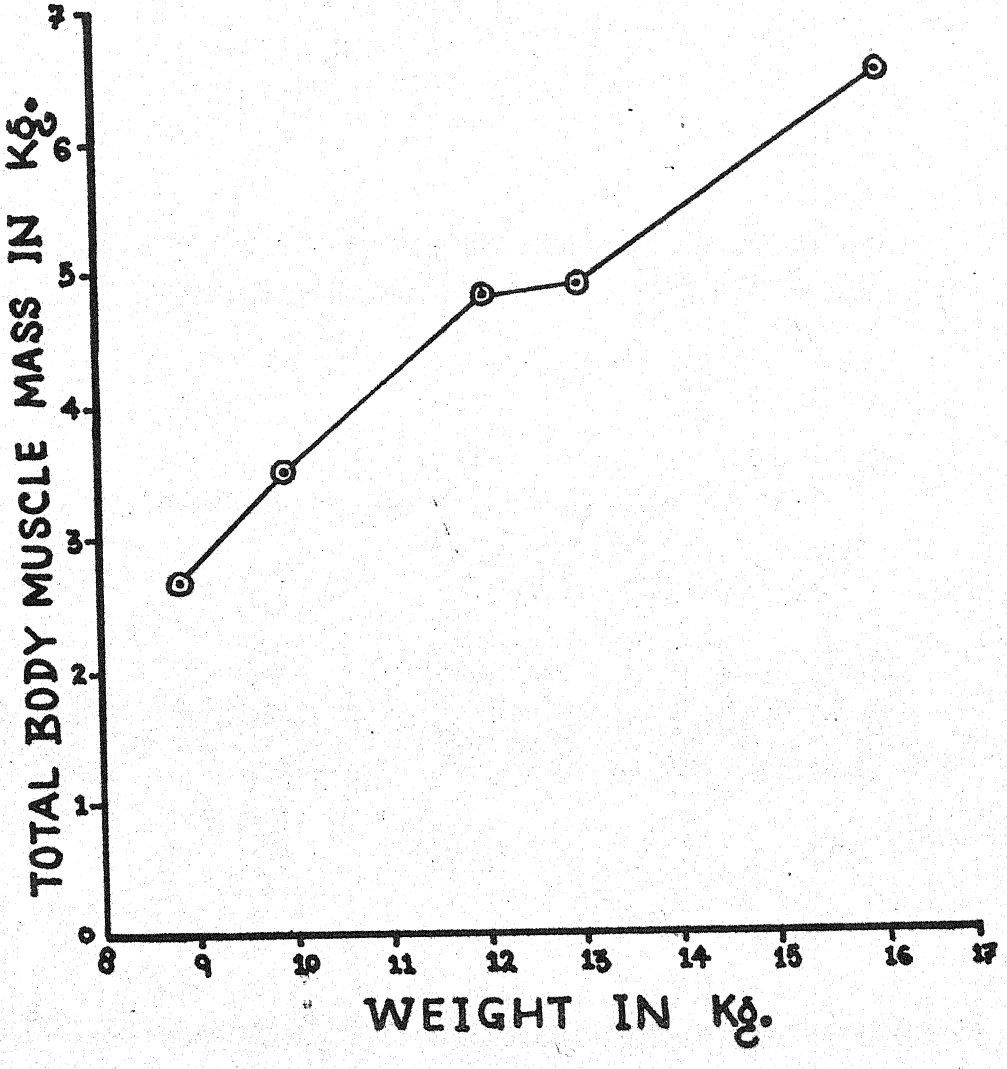


fig- 6.

GRAPH SHOWING RELATIONSHIP OF
TOTAL BODY MUSCLE MASS AND HEIGHT/LENGTH

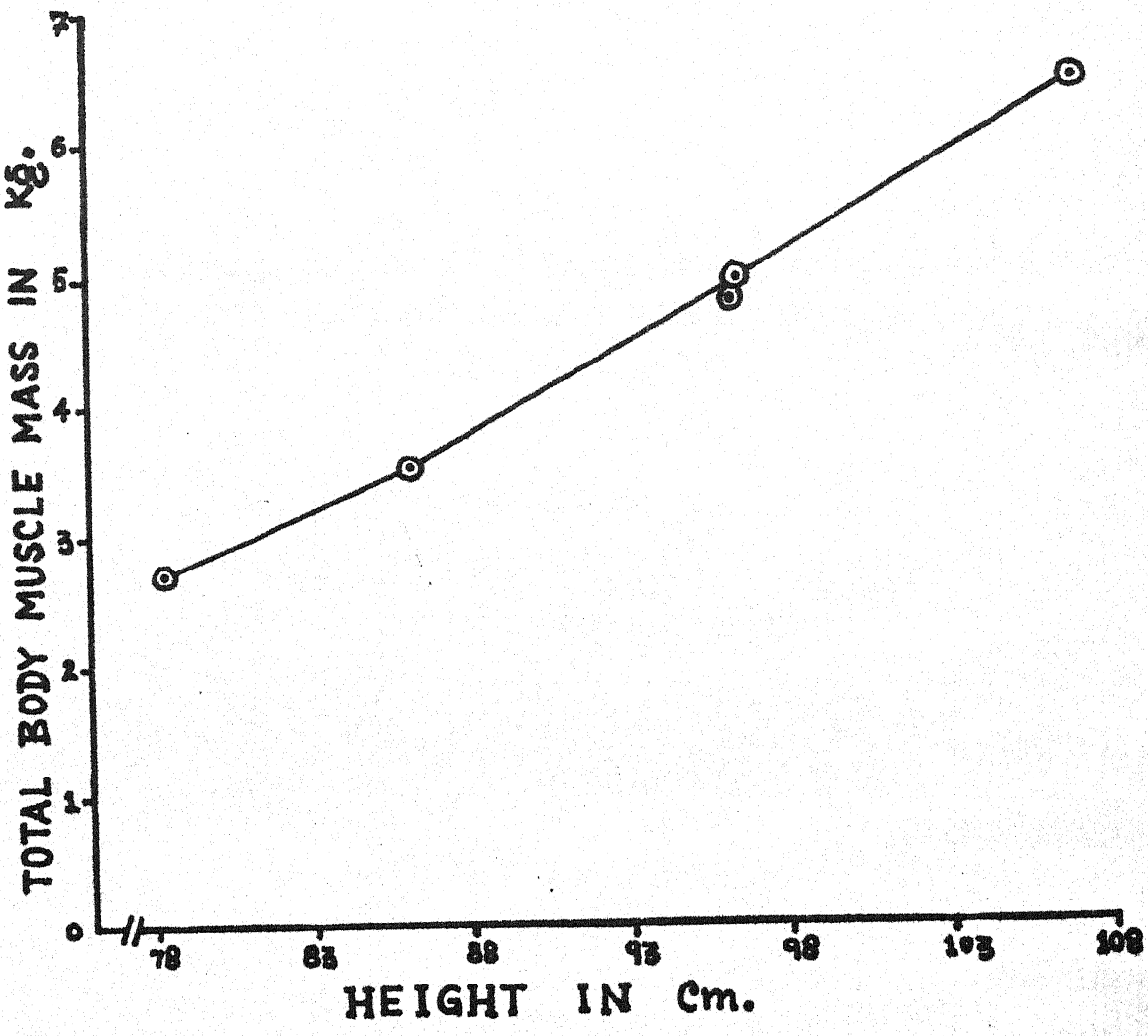


fig-7.

GRAPH SHOWING RELATIONSHIP OF
TOTAL BODY MUSCLE MASS AND MID-ARM CIRCUMFERENCE

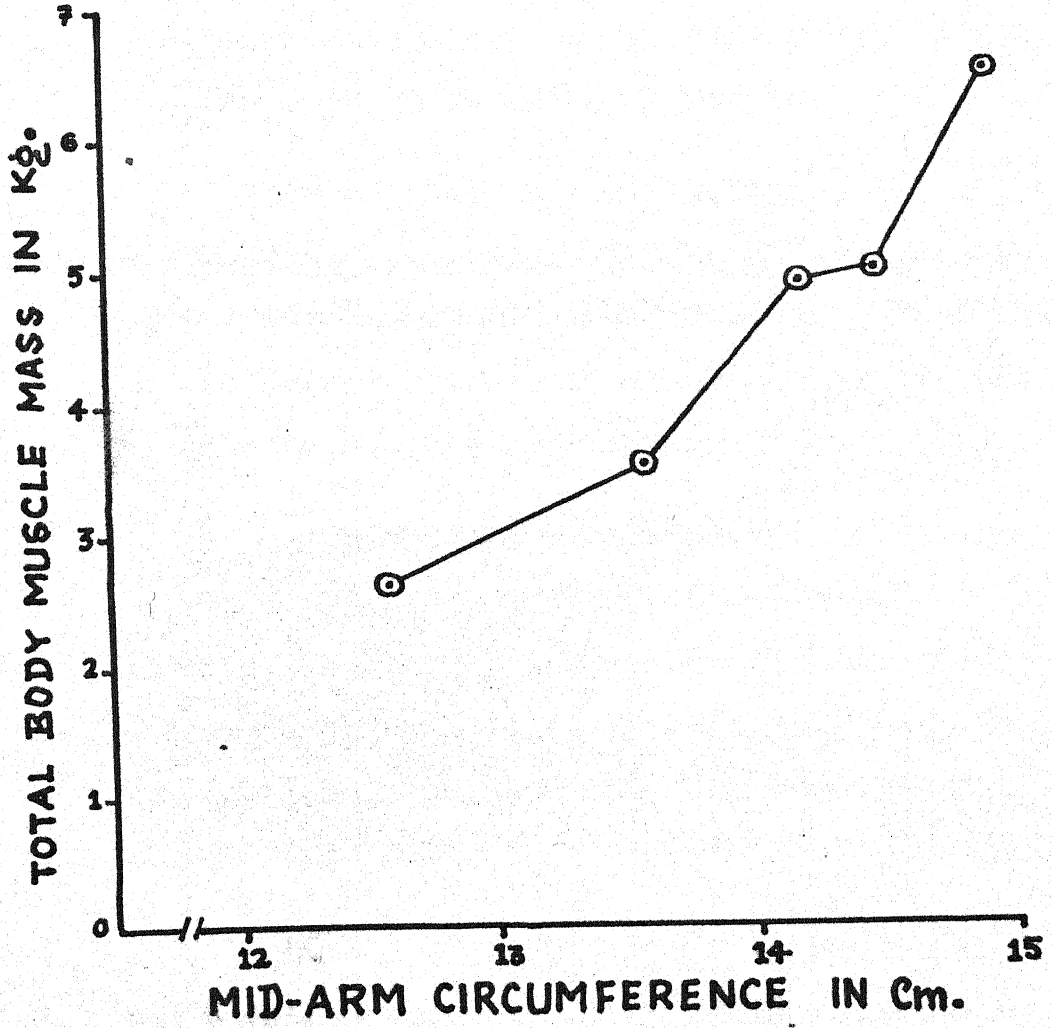


fig. 8.

No statistical significant correlation was found between head circumference and age and weight. While it was statistically significant when calculated for height, maximum-calf circumference and chest circumference. The correlation coefficient of head circumference to age was + 0.18, to weight + 0.19, to height + 0.34, to maximum-calf circumference + 0.55 and to chest circumference was + 0.37.

The correlation coefficients of chest circumference to age, weight, height and maximum calf circumference were + 0.50, + 0.38, + 0.49, and + 0.59 respectively. These correlations were found to be statistically significant.

Table VI also pointed out the statistically significant correlationship of maximum-calf circumference to age, weight and height. The correlation coefficients of maximum-calf circumference to age, weight and height were + 0.65, + 0.53 and + 0.65 respectively.

The correlation coefficient of height to age was + 0.82 and to weight was + 0.88. The 't-tests' showed a statistical significant correlation.

The correlation of weight to age was also significant and the correlation coefficient was + 0.76.

Table VII

Simple regression equations of TBMM (Y) on different independent variables viz. age, height, weight, MAC, MCC, HC and CC.

S.No.	Name of independent variable (x)	Value of constant (a)	Regression coefficient (b)	% Coefficient of determination
1.	Age in months	+ 1.351	+ 0.074*	57.76
2.	Height in Cm.	- 11.878	+ 0.176*	94.09
3.	Weight in Kg.	- 0.840	+ 0.451*	79.21
4.	MAC in Cm.	- 14.706	+ 1.376*	67.24
5.	MCC in Cm.	- 26.587	+ 1.794*	38.44
6.	HC in Cm.	- 12.889	+ 0.381*	25.00
7.	CC in Cm.	- 9.398	+ 0.295*	2.89

TBMM = Total body muscle mass
MAC = Mid-arm circumference
MCC = Maximum-calf circumference
HC = Head circumference
CC = Chest circumference

* ($p < 0.01$)

equation : $Y = a + bx$

Table VII represents the single variate regression equations of total body muscle mass (TBMM) on different independent variables viz. age, weight, height, head circumference (HC), chest circumference (CC), mid-arm circumference (MAC) and maximum-calf circumference (MCC). The equation is as follows - $Y = a + bx$, where y is dependent variable TBMM, a is a constant, b is regression coefficient and x is the independent variable.

The regression equation of TBMM on age was found as follows :-

$$Y = 1.351 + 0.074\ x.$$

where the value of constant is + 1.351 and the value of regression coefficient is 0.0742.

The regression equation of TBMM on height/ length was calculated as follows :-

$$Y = 0.176\ x - 11.878.$$

where the value of constant is - 11.878 and the regression coefficient is 0.176.

The regression equation of TBMM on weight was as follows :-

$$Y = 0.451\ x - 0.84.$$

where 0.451 is regression coefficient and - 0.84 is constant.

The regression equation of TBRM on NAC was as follows :-

$$Y = 1.374\ x - 14.706.$$

The value of constant is - 14.706 and the value of regression coefficient is 1.374.

The regression equation of TBRM on NCC was found as follows :-

$$Y = 1.794\ x - 26.587,$$

where 1.794 is regression coefficient and the value of constant is - 26.587.

The regression equation of TBRM on NC was -

$$Y = 0.381\ x - 12.869,$$

where 0.381 is regression coefficient and - 12.869 is value of constant.

The regression equation of TBRM on CC was calculated and found it as follows :-

$$Y = 0.295\ x - 9.398,$$

where the value of constant is + 9.398 and the regression coefficient is 0.295.

The 't-tests' were applied and they were found to be statistically significant ($P < 0.01$).

When multiple variate regression equation was derived, the values and the equation of total body muscle mass (TBMM) on height/length, weight, mid-arm circumference (MAC), maximum-calf circumference (MCC), head circumference (HC) and chest circumference (CC) was found as follows :-

$$\text{TBMM} = -8.518 + 0.121 \text{ height} + 0.024 \text{ weight} + 0.162 \text{ MAC} - 0.068 \text{ MCC} + 0.002 \text{ HC} + 0.007 \text{ CC}.$$

The % coefficient of determination was 96.67.

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DISCUSSION

DISCUSSION

The present cross-sectional study was carried out over ninety apparently normal children of Jhansi, during July 1982 to April 1983. The selected children belonged to pre-school age group (1-6 years). This age group was selected as there is paucity of data in Indian and world literature regarding the observations on creatinine excretion and total body muscle mass.

A set of six anthropometric measurements viz. weight, height/length, head circumference, chest circumference, mid-arm circumference, maximum calf circumference, were recorded in each child. A statistical analysis of correlation and regression was done between external (anthropometric measurements) and internal (total body muscle mass) growth parameters. There is no consensus of opinion regarding the effect of dietary proteins level over creatinine excretion (Hunter 1928, Beard 1943, Best et al 1952, Miller 1952, Best 1953, Standard et al 1959). To minimise the effect of diet, all the children were placed on a low creatinine diet prior to and during the study.

24 HRS CREATININE EXCRETION IN RELATION TO AGE AND SEX

In our study the creatinine excretion in 24 hrs. ranged from 0.13 (± 0.02) gms to 0.32 (± 0.04) gms in the age group of one to six years. Rising trend of creatinine excretion was observed in both sexes with age. In the boys it increased from 0.13 (± 0.02) gms/24 hrs at 1 year to 0.32 (0.05) gms/24 hrs at 6 years, while in girls (2-6 years) the excretion of creatinine increased from 0.14 (± 0.02) gms to 0.31 (± 0.02) gms in 24 hrs urine (Table XII, Fig. 2). Talbot et al (1938) also observed a linear correlationship between age and 24 hrs creatinine excretion. However, they studied older children (7-12 years) and total urinary creatinine excretion in 24 hrs in their study ranged from 0.385 gm to 0.731. Clark et al (1951) while studying the children and adolescent between 5 to 17 years of age also found an increase in creatinine excretion with age. The values in their study ranged from 0.36 gm/24 hrs to 1.59 gms/ 24 hrs. The findings of Graystone et al (1968) also in agreement with our findings. Cheek et al (1968) too reported a direct correlationship between age and 24 hrs creatinine excretion. Girls showed a linear relationship with greater variability. The boys, however, exhibited a quadratic relationship. Wakefield et al (1980) studied urinary creatinine concentration

in two different racial groups - black and white girls between 9 to 11 yrs of age of middle and low income group. They too found an age associated change. Seth et al (1981), while studying 16 pre-school male children found that the average creatinine excretion in 24 hrs was 225.4 ± 78.0 mgs.

The present study didn't show any significant difference ($P > 0.05$) in 24 hrs urinary creatinine excretion levels in boys and girls except in children of group C where boys had significantly higher excretion than girls ($P < 0.01$). This difference could be attributed to the population difference. While Cheek et al (1968) also didn't find any sex difference in their study sample, whereas Clark et al (1951) found its values on higher side in boys than girls who were near the pre-adolescent age, i.e. 12-14 years and at age of 15 years.

CREATININE WEIGHT COEFFICIENT

The creatinine weight coefficient (mg/24 hrs/kg) in present study ranged from 14.68 to 20.00 in 1-6 years old boys while in girls it increased from 16.27 at 2 years to 21.30 at 6 years of age. Though in combined population it ranged from 14.68 to 19.90 in studied age group (Table IV, Fig. 3). The pattern of increase of creatinine weight coefficient was not linear with age.

The creatinine weight coefficient values so far have not been reported in appreciable number of cases in different age groups of pre-school children. However, Hunter (1928) found creatinine weight coefficient to be 2.7 at birth it rose from 5.5 to 8 within few months. At three years the value increased from 11 to 13 and then again in ninth year from 13 to 19. Creatinine weight coefficient of 10.66, the lowest average and 12.98 the highest average was observed by Daniels et al (1929) in infants below 7 months of age. Talbot et al (1938) found that creatinine weight coefficient values ranged from 15.3 to 27.5 in children who were 7-12 years of age.

Clark et al (1951) reported a significant difference in this ratio between boys and girls, it was 25 ± 1 and 21 ± 1 in boys and girls respectively. Cheek et al (1966) derived the creatinine weight coefficient as 0.6143 (age) + 12.764 (r = 0.66, S.D. ± 2.31 mg/kg/24 hrs) in 19 normal boys and 0.5633 (age) + 11.916 (r = 0.71, S.D. ± 2.04 mg/kg/24 hrs) in 20 normal girls. They concluded that there was no sex difference in their observed group.

CREATININE LENGTH/HEIGHT COEFFICIENT

In the present study creatinine length/ height coefficient (mgs/24 hrs/cm) increased from 1.66 to 2.97 in male. Whereas it ranged from 1.73 to 2.92 in girls, while in combined population the value of coefficient rose from 1.66 at 1 yr to 2.98 at 6 yrs of age (Table XV, Fig. 4). It showed a linear relationship with age, so it is better index to predict muscle mass than creatinine weight coefficient. Daniels et al (1928) reported that creatinine length/height coefficient increased with increasing age (below 7 months), its average value was 1.16 mg/24 hrs/cm. Clark et al (1951), Cheek et al (1966, 1968) and Viteri et al (1970) though didn't derive creatinine length/height coefficient but found a good correlation between 24 hrs creatinine excretion and body length/height.

TOTAL BODY MUSCLE MASS

Total body muscle mass showed a gradual upward trend in both boys and girls, its value ranged from 2.73 (± 0.48) kg at 2 years to 6.51 (± 0.87) kg at 6 years in combined population (Fig. 5). In boys the total body muscle mass varied from 2.73 (± 0.48)kg to 6.53 (± 1.05) kg while in girls values were

2.98 (± 0.48) kg to 6.47 (± 0.15) kg. There was no statistically significant difference in values of total body muscle mass of boys and girls of group C, D and E ($P > 0.05$), whereas it was significant in group B ($P < 0.05$). Cheek et al (1966, 68) found that it ranged from 0.92 kg to 27.82 kg in children aged 0.18 to 16.06 years. Seth et al (1981) also calculated the muscle mass from 24 hrs creatinine excretion and found the total body muscle mass to be 4.5 ± 1.56 kg as an average for pre-school children.

The coefficient of correlation between the different growth parameters study showed that they were all positive and except head circumference with age and weight; and total body muscle mass with chest circumference, were very highly significant. The correlations of total body muscle mass with height/length, weight, mid-arm circumference (Fig. 6, 7 and 8), age, maximum-calf circumference and head circumference were respectively 0.97, 0.89, 0.82, 0.72, 0.62 and 0.59. This shows that height/length with coefficient of determination 94.09% or even weight with coefficient of determination 79.21% could individually be used for estimation of total body muscle mass. This is in confirmation with the results by Cheek et al (1968) who have reported correlations are 0.93 and 0.92 respectively for the infants and children. The high

correlation (0.91) with age as reported by them was, however, not found in this study, may be because data on age was obtained through enquiry.

In the study by Seth et al (1981), the order of the parameters with decreasing values of coefficients of correlation were height/length, head circumference, age, weight and mid-arm circumference. The last one was being not significant (r = 0.02). These results are somewhat variant with those of the present study. The comparison of mean values of the parameters show head circumference and mid-arm circumference values in present study are lower than values obtained by Seth et al, which could be attributed to the differences in the population.

The present study confirms the earlier reports that the total body muscle mass is the best correlated to anthropometric measurement - height/ length. To see if any further improvement could be made in the prediction of total body muscle mass by the use of additional anthropometric measurements, the multiple linear regression of total body muscle mass on all the other parameters except age (obtained by enquiry) was fitted.

The fitted regression is as follows :-

TBM (Kg) = -8.518 + 0.121 height (cm) + 0.024 weight(kg)
+ 0.162 MAC (cm) - 0.068 MCC (cm)
+ 0.002 HC (cm) + 0.007 CC (cm)

(R^2 = 96.67%)

which could only be explained 96.67% of variation as against the 94.1% by the simple regression on height/length alone. Thus it could be concluded that for the population studied height/length alone could be used for the prediction of total body muscle mass value in normal children.

In acute malnutrition where height/length is least affected, this anthropometric measurement alone would not give the correct prediction of total body muscle mass. Therefore, the predicted values of total body muscle mass by using the height/length alone will give the higher values for total body muscle mass. In such cases, either we should use the studied set of anthropometric measurements or weight alone (R^2 = 79.21%), to predict the total body muscle mass in population.

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SUMMARY AND CONCLUSION

Any urine sample which contained glucose or acetone, was discarded from the study.

In pooled population, the average creatinine excretion in 24 hrs ranged from 0.13 (± 0.02) to 0.32 (± 0.04) gms in pre-school children. The mean values for boys ranged from 0.13 (± 0.02) gms/24 hrs at 1 yr to 0.32 (± 0.05) gms/24 hrs at 6 yrs of age. The values for girls were found to be 0.14 (± 0.02) gms/24 hrs at 2 yrs and 0.31 (± 0.02) gms/24 hrs at 6 yrs. The difference of creatinine excretion in boys and girls was statistically not significant except for 4 to 5 yrs of age.

The creatinine weight coefficient (mg/24 hrs/kg) was found to increase with age. The creatinine weight coefficient (C.W.Co.) was calculated, the average values rose from 14.68 mg/24 hrs/kg to 19.90 mg/24 hrs/kg in combined population. The boys had the values ranging from 14.68 mg/24 hrs/kg to 20.00 mg/24 hrs/kg while in the girls the range was from 16.27 mg/24 hrs/kg to 21.30 mg/24 hrs/kg.

The creatinine length/height coefficient (mg/24 hrs/cm) showed more linear correlation with age. The creatinine length/height coefficient (C.H.Co.) in studied population ranged from 1.66 mg/24 hrs/cm to 2.98 mg/24 hrs/cm. In boys it rose from 1.66 mg/24 hrs/cm at 1 yr to 2.97 mg/24 hrs/cm at 6 yrs while the values

of girls were also in an increasing trend from 1.73 mg/24 hrs/cm to 2.92 mg/24 hrs/cm.

The total body muscle mass was calculated by multiplying 24 hrs urinary creatinine excretion in grams to 20 (Cheek's factor). An upward rise was observed in calculated values with age. At the age of 12 +, 25 +, 37 +, 49 + and 61 + months, the pooled children had total body muscle mass of 2.73 (± 0.48) kg. 3.58 (± 0.74) kg, 4.94 (± 0.87) kg. 4.91 (± 1.01) kg and 6.51 (± 0.87) kg respectively. The boys had the total muscle mass of 2.73 (± 0.48) kg at 1 yr and 6.53 (± 1.05) kg at 6 yrs of age. The values for girls were ranging from 2.98 (± 0.48) kg to 6.47 (± 0.15) kg. The difference in values of boys and girls were found statistically insignificant except in 25-36 months of age.

A set of six external growth parameters viz. weight, length/height, head circumference (HC), chest circumference (CC), mid-arm circumference (MAC), maximum-calf circumference (MCC) was recorded in each child.

The mean body weight of all children was 12.36 (± 2.89) kg with average of 8.85 (± 1.65) kg and 16.15 (± 1.28) kg at two extreme ages of our study. The mean weight of each child was 85% or more than that of 50th percentile of Harvard standards.

The average height/length was 78.31 (± 4.71) cm at 13 + months, 86.40 (± 6.61) cm at 25 +, 96.56 (± 6.39) cm at 37 +, 96.59 (± 5.62) cm at 49 + and 107.03 (± 5.63) cm at 61 + months of age.

The average M.C. was found to be 46.26 (± 2.08) cm in pooled population. It ranged from 44.59 (± 4.06) cm to 47.80 (± 0.86) cm in pre-school children.

The mean value of C.C. was 47.95 (± 2.54) cm in total population. The lowest value was 45.58 (± 3.32) cm and the highest was 49.63 (± 2.23) cm.

The average M.A.C. was found to be 14.15 (± 0.99) cm. It increased from 12.60 (± 0.50) cm to 14.97 (± 0.77) cm in studied children.

The average M.C.C. was observed to be 17.46 (± 1.39) cm with the lowest value of 15.27 (± 1.31) cm and the highest being 19.86 (± 1.19) cm.

A statistical analysis of correlation and regression was done. The correlation coefficients between different external growth parameters showed a significant positive correlation except for head circumference with age and weight. Similarly correlation coefficient of total body muscle mass (internal growth parameter) and various anthropometric

measurements (external growth parameters) revealed the significant correlation except for total body muscle mass with chest circumference. The correlations of total body muscle mass with height/length, weight, mid-arm circumference, age, maximum-calf circumference and head circumference were 0.97, 0.89, 0.82, 0.72, 0.62 and 0.59 respectively. The coefficient of determination with length/height was the highest (94.09%), the second best being with weight (79.21%).

Further, a simple single variate linear regression equation was derived of total body muscle mass (kilograms) on age and on each component of anthropometric set. They were found as follows in decreasing order of coefficient of determination -

1.	TBMM = + 1.351 + 0.074 age	(R^2 = 57.76%)
2.	TBMM = -11.878 + 0.176 height	(R^2 = 94.09%)
3.	TBMM = - 0.840 + 0.451 weight	(R^2 = 79.21%)
4.	TBMM = -14.706 + 1.374 MAC	(R^2 = 67.24%)
5.	TBMM = -26.587 + 1.794 MCC	(R^2 = 38.44%)
6.	TBMM = -12.889 + 0.381 HC	(R^2 = 25.00%)
7.	TBMM = - 9.398 + 0.295 CC	(R^2 = 2.8%)

Note : + age in months.
- TBMM and weight in kilograms.
+ Ht, MAC, HC and CC in centimeters.

To see if any further improvement could be made in the prediction of total body muscle mass by the use of additional anthropometric measurements, the multiple variate linear regression equation of TBMM on the set of anthropometric measurements was fitted. That was -

---

TBMM (kg.) = - 8.518 + 0.121 ht (cm.)
+ 0.024 wt. (kg.) + 0.162 M.A.C. (cm.)
- 0.068 M.C.C. (cm.) + 0.002 M.C.(cm.)
+ 0.007 C.C. (cm.)

(R^2 = 96.67%)

which could only explained 96.67% of variation as against the 94.09% by the simple regression on height/length alone.

Thus it is concluded -

1. The creatinine excretion in 24 hrs urine increased with age.

2. There was no sex difference in creatinine excretion in our study except in the age group of 4-5 yrs where the boys had statistically higher values than the girls.

3. The creatinine weight coefficient (C.W.Co.), i.e. mg/24 hrs/kg didn't show the exact linear relationship.

4. The creatinine length/height coefficient (C.H.Co.) showed almost a linear correlation with age.

5. Total body muscle mass showed an increasing trend with age. Boys were having statistically more muscle mass than the girls in the age group of 2-3 years.

6. The anthropometric measurement length/height was the best correlated with total body muscle mass and it explained 94.09% variation when fitted in simple regression equation.

7. The second best correlated anthropometric measurement was the body weight, which explained 79.21% of variation when fitted in simple regression equation.

8. The multiple variate regression equation of total body muscle mass on different anthropometric measurements was fitted, which could only explain 96.67% of variation as against the 94.09% by simple regression equation on length/height alone in normal children.

9. In cases of acute malnutrition where length/height is the least affected anthropometric measurement, it would give an erroneous value if total body muscle mass was to be calculated by length/height alone. Thus, it is advocated that we should either use body weight (R^2 = 79.21%) alone or make use of multiple regression equation of all the anthropometric measurements studied (R^2 = 96.67%).

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APPENDIX

APPENDIX

WORKING CASE SHEET

Name ..... Case No. .....

Age ..... yrs ..... months Sex : M / F

Father's name ..... M.R.D. No. .....

Address ..... D/A .....

..... D/D .....

Socio-economic History : Rural / Urban.

	Father	Mother
Age		
Education		
Occupation		
Income (per month)	Rs.	Rs.

Total family income : Rs.

Total family members :
Above 12 yrs .....
Below 12 yrs .....

Per capita income : Rs.

Water Supply : Central/Well/Tube well.

Genological tree :

Dietary History :

	Started at age	Upto age	Dilution	Amount (per day)
Breast milk (if not received - L.F./Not willing/Not sufficient				ml
Supplimentation - Pure/ Marketed, cow/buffalow/ goat/mixed				ml
Powdered milk			..... %	
			..... ml	ml

Drug supplimentation : Not given/Cap. A.D./ Iron tab./Folic acid tab.

Present diet(in form of):

.....

.....

Solids

Present diet : Calories ..... Proteins.....gm/day

Diet deficient in calories/Proteins/Both/Not deficient.

Immunization History :

	Age		Age
Smallpox		B.C.G.	
Polio I		D.P.T. I	
II		II	
III		III	
Booster I		Booster I	
II		II	

Antenatal History : Antenatal visits - 1, 2, 3 / No

Positive History : drug intake/radiation/Trauma/A.P.H./Exanthematous fever/Toxaemia (I T, II T, III T).

Natal History : Hospital / Home delivery
Term / Pre-term (mths .....)
Mode of delivery - N / C / F Br./ Tw

Post-natal History (1st 4 wks) :

No problem/Cyanosis/Jaundice/Umbilical sepsis/Convulsions +

Developmental History :

1. Motor :-	Age	2. Manupulative :	Age
Head control	.....	Grasp	.....
Sitting with support.....		Self feeding	
Sitting without support---		- Cup	.....
Stand with support	.....	- Spoon	.....
Standing without support...		Help in dressing	.....
Walking	.....	3. Social :	
		Social smile	.....
		Recognise his name	.....
		4. Speech	.....

Comments, if any : .....

Family History :

Suggestive history of tuberculosis / ..... +/-

Present illness : Passing urine freely (..... times/day)
No/Yes

Past illness :

Positive History - Recurrent URTI/Loose motions/Worm infestation/Measels/Whooping cough/ Recurrent vomiting/Jaundice (duration.....)

Clinical Evaluation :

- General appearance - Healthy / Malnourished
- Psychomotor changes- Fretful / Listless
- Hair - Normal / Abnormal
  Colour .....
  Easy pluckability : +/-

- Mouth - N/Stomatitis/Glossitis/Swollen bleeding gums.

- Dentition - No. of teeth ..... at .....
  Shape - N/abnormal
  Enamel - N/abnormal (colour.....)
  Caries - +/Not present.

- Lymphnodes - NP / P (C/A/I/G) R/L/Both
  If palpable - size .....
  tender / non-tender
  discrete / matted.

- Skin - N/abnormal (dry, rough)
  Oedema -/+ (feet, sacral, generalized)
  Pigmentation -/+ (site .....)
  Dermatosis ...../not present.

- Subcutaneous loss - -/+ (site .....)

- Muscle wasting - -/+

- Skeletal - Ant. fontanel (open/closed.....tnble)
  Wrist widening -/+ (Rt./Lt./Both)
  Frontal bossing -/+
  Rickety rosary -/+

- Abdomen :
  Shape - N/Scaphoid/Full/Distended
  Liver ..... Cm. palpable
  Spleen ..... Cm. palpable
  Any abnormality .....

- C.V.S. :
  N/any abnormality .....

- Respiratory system :
  N/any abnormality .....

- C.N.S. :
  N/Any abnormality .....

- External genitalia : N/abnormal
  Signs of inflammation -/+

Anthropometric measurements :

Weight	Kg.
Length or Height	Cms.
Head circumference	Cms.
Chest circumference	Cms.
Mid-arm circumference	Cms.
Maximum Calf circumference	Cms.

Investigations :

Blood :

1. Haemoglobin - ..... gm%
   T.L.C. - ..... /cub. mm.
   D.L.C. - P L E M
2. Serum proteins - ..... gm%
   A/G ratio - .....
3. Serum creatinine - ..... mg/dl.

Urine :

1. Proteins ..... sugar ..... acetone .....
   Microscopic .....
2. Creatinine in 24 hrs sample .....
   (amount ..... ml.).

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CLOSED INTRAMEDULLARY NAILING. IN THE TREATMENT OF FRESH. SIMPLE FRACTURES. OF SHAFT OF TIBIA



HESIS

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GOVIND JI SETHI

CLOSED INTRAMEDULLARY NAILING. IN THE TREATMENT OF FRESH. SIMPLE FRACTURES. OF SHAFT OF TIBIA

THESIS

FOR

MASTER OF SURGERY

(ORTHOPAEDICS)



D 1301

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C E R T I F I C A T E

This is to certify that the work of Dr. Govind Ji Sethi on "Closed Intramedullary Nailing In The Treatment of Fresh Simple Fractures of Shaft of Tibia" which is being presented by him as a thesis for M.S. (Orthopaedics) was conducted in the Department of Orthopaedics, M.L.B. Medical College, Jhansi.

He has put in the necessary stay in the department according to the University regulations.

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C E R T I F I C A T E

This is to certify that the work of Dr. Govind Ji Sethi on "Closed Intramedullary Nailing In the Treatment of Fresh Simple Fractures of Shaft of Tibia" which is being presented by him as a thesis for M.S. (Orthopaedics) was conducted under my direct supervision and guidance.

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ACKNOWLEDGEMENT

It is my proud privilege to express my profound sense of gratitude to my esteemed guide and teacher Prof. P. K. Dabral, M.S., Head, Department of Orthopaedics, M.L.B. Medical College, Jhansi, who with his unfathomed knowledge and untiring zest for work guided me throughout this venture. His keen interest, invaluable suggestions and constant supervision went a long way towards the final shaping of this work.

I am deeply indebted to Dr. Anurag, M.S., Lecturer, Department of Orthopaedics, M.L.B. Medical College, Jhansi for his overhelping attitude and everinspiring guidance without which it would not have been possible to start, much less finish, the present work.

I acknowledge with sincere thanks to Dr. R.P. Tripathi, M.S., Reader, Department of Orthopaedics, M.L.B. Medical College, Jhansi for his kind equiescence to perform this study and bringing it to the present state.

I am highly obliged to Dr. D.K. Gupta, M.S., Lecturer, Department of Orthopaedics, M.L.B. Medical College, Jhansi for the encouragement and keen interest at every stage of this work.

This task could not have been possible of completion but for the co-operation of my colleagues in the department. I am thankful to Mr. Phool Chandra Sachan for his hard labour in preparing the typescript of the text.

Govind Ji Sethi

(Govind Ji Sethi)

C O N T E N T S

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INTRODUCTION

INTRODUCTION

With the advent of modern civilization the life of people have become more comfortable. The distances have shortened and the time has expanded. But along with these its inevitable evils have also followed it. Increasing mechanisation at home, farm, road or place of work and increasing vehicular traffic has lead to an increase in various types of accidents involving death and disability of an enormous magnitude.

Fracture of the tibia is one of the commonest fracture of lower extremity which by virtue of its location and position offer many problems in its treatment. As one third of its surface is subcutaneous through most of its length, open fracture are common in the tibia than any other major long bone. Furthermore the blood supply to the tibia is more precarious than that of bones enclosed by thick muscles. The presence of hinge joints at the knee and ankle allows no adjustment for rotatory deformity after fracture and thus special care is necessary during reduction to correct such deformity. Delayed union, non-union and infection are frequent complications after fractures of tibial shaft.

From the days of Sushruta (1000 B.C.) a number of methods of the treatment of fractures of tibial shaft have been devised till date. On one hand there is a view that these fractures should primarily be treated with conservative methods. On the other hand, there are surgical techniques

for fixation by plates, intramedullary nails and highly mechanical external fixator. In the words of Sir John Charnley (1961) "We have still a long way to go before the best method of treating a fracture of the shaft of the tibia can be stated with finality".

Several large series of tibial shaft fractures have been studied during the past. The studies of Dehne et al (1961), Andersen and Hutchins (1961), Weissman et al (1966), Hoagland and States (1967), Sarmiento (1970) and many others concluded the recommendation of closed treatment. Nicoll (1964) in the study of 674 cases found that union without deformity and good functional results occurred in 95 percent of cases treated conservatively.

The immobilisation of limb from toe to groin plaster of paris cast is most commonly used conservative method. In stable fractures it is a satisfactory method but in unstable ones it is very difficult to maintain the reduced position only by plaster cast resulting into malunion, delayed union or non union. Patients require prolonged immobilisation in this conventional method which leads to joint stiffness, muscles wasting, osteoporosis, thromboembolic phenomenon and above all psychic disturbances.

External fixation devices have enjoyed long periods of enthusiastic use. They afford certain advantages owing to more rigid fixation, early mobilisation protective care for wound without disturbing the fracture alignment or fixation and thus causing least joint stiffness, oedema

muscle atrophy and osteoporosis. The highly mechanized metallic fixation devices have some disadvantages : being costly and difficult in assembling the fixator by the uninitiated surgeon.

Open reduction and internal fixation, although results in good anatomical reduction and rigid immobilisation avoiding a few of the complications of conventional closed method, yet carries a definite risk of anaesthesia, infection and delayed union. This method cannot be applied routinely in high risk patients.

Open reduction and internal fixation disturbs the normal healing process by periosteal stripping and draining of the fracture haematomas. Moreover, supporters of internal fixation have not proved a decreased incidence of non-union as a result of operative treatment.

Ellis of Great Britain has summed up the problem as follows "However attractive the possibilities of operative treatment may seem, operation still entails the conversion of a closed fracture into an open one, and the consequent risk must be weighed against the theoretical advantages". According to Mour (1968) "I make this appeal, keep the closed fracture closed".

The introduction of strong clover leaf nail combined with principle of reaming out the medullary canal (Kuntscher, 1958) and the development of image intensifier have reviewed interest in closed nailing. Lottes (1952) Kuntscher (1958) and Bohler (1965) have reported encouraging results with such technique.

Still this method is not in common use and is practised only in big centres because of certain limitations such as a specialised traction device and image intensifier. There are certain advantages of the above said procedure such as :

1. It inflicts minimal surgical trauma.
2. Fracture haematoma is least interfered with.
3. Cancellous bone from within the medullary canal is driven into fracture haematoma thus conferring it with considerably more osteogenic potential.
4. Periosteal blood supply is not disturbed.
5. Infection is low or practically ruled out.

Since the technique used at various centres in developed countries entails the use of expensive apparatus and sophisticated instruments, this is not always available in a developing country as ours. We propose to simplify the technique of closed nailing in fresh simple fractures of shaft of tibia.

AIMS OF CLOSED NAILING

1. To decrease the rate of infection.
2. To decrease the time of hospitalisation and period of disability.
3. Early mobilisation and good range of joint movements.
4. To decrease the rate of non-union, delayed union and malunion.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The treatment of fractures of tibial shaft has become one of the most controversial subject in orthopaedic surgery. In the past years many methods of treating fractures of tibial shaft have been presented and there have also been many analyses of the end results of such treatment.

Sushruta has described the fractures as "Kanda Bhang". Various type of fractures and dislocations are described in Sushruta Samhita. In the treatment of the fractures of lower extremities "Kapat-Shayana" (Door bed) or a fracture board consisting of a plank of wood resembling the panel of a door were used. For the fracture of the lower limb after making the patient lie on the bed, the injured limb was immobilised with the help of pegs.

Apart from these references, no clear concept of treatment of fractures particularly of lower limb was available till the middle of 18th century. Hippocrates was the first to study the effect of muscle spasm on fractures which caused shortening and over riding. Hence splinting the limb to overcome these problems became popular in the middle of 18th century.

Impressive results have been cited to support both open (Linden, 1938 and Veliskakis, 1959) and closed methods (Alder, 1962; Edward, 1965; Sarmiento, 1970) of treatment for fracture shaft tibia.

The clinical problem of the tibial fracture is seen by the multiplicity of therapeutic methods which exists (Alder et al, 1962). These methods can be divided as follows :

1. Conservative method - closed reduction followed by plaster immobilisation.
2. Open/closed reduction and internal fixation with or without A.O. or A.S.I.F. techniques.
3. Closed reduction followed by immobilisation by external fixator.

No method of treatment is applicable to all types of fractures of the tibial shaft which are encountered under various circumstances. Various workers have reported the results of different methods of treatment.

CONSERVATIVE TREATMENT OF FRACTURE TIBIA

Oskar Linden (1938) observed in a study of 52 cases treated by conventional method, the average healing time was 22.3 weeks. The average shortening was one to two cm with five to ten degree of valgus deformity in 38.4 percent and varus deformity in twenty five percent cases.

Griffith (1942) analysed 249 cases of fractures of both bone in the patients treated by closed method of reduction with above knee plaster of paris cast. The mean time for union was 16.5 weeks and eight cases had non-union.

Robert Funstein (1945) reviewed 149 cases of fracture of both bones leg and found average healing time to be 11.2 weeks for clinical union and 30.4 weeks for radiological union. Types of fractures made practically no difference in the rate of healing.

Carpenter (1952) and Jackson (1959) concluded that 95 percent of tibial shaft fractures, whether simple comminuted or compound can be adequately managed by closed reduction with the advantage that such conservative means will avoid serious complications and will enable the fractures to heal in a shorter period than a similar fracture treated by open reduction and internal fixation. Their conclusion is that initial haematoma around a fracture contains osteogenic properties which help in healing of the fracture. If this haematoma is exposed to external environment by open reduction, not only the union of fracture is delayed but also chances of infection increase.

Selheim (1960) studied 500 tibial shaft fractures treated by either closed reduction and plaster of paris cast or open reduction and internal fixation. He found that healing time was shortest with conservative method and that the transverse fractures united earlier.

Nicoll (1964) in a survey of 705 cases of which 674 cases of tibial shaft fractures were treated conservatively. He observed the average time of union of fracture was 16 weeks (12 to 20 weeks). Incidence of delayed and

non union in infected cases was 60 percent. Intact fibula showed to hasten the process of healing. Twenty five percent of cases had foot and ankle stiffness. He also stated that internal fixation can be justified on grounds that it reduced the incidence of functionally significant deformity and joint stiffness, it significantly lowered the incidence of delayed and non-union.

Edward (1965) treated 492 fractures with closed reduction and plaster application. The results after one year were analysed as good, fair and poor. Longitudinal fractures showed 85 percent good, 15 percent fair while the transverse fractures showed 95 percent good , five percent poor results. Union time was nine months in closed transverse fractures and fourteen months in open transverse fractures. Complications such as skin necrosis osteomyelitis and mal union were observed in four cases.

Weissman and Herald (1966) treated tibial shaft fracture without internal fixation in 150 cases and found that the average time of union was four months and seventeen days along with average time of hospitalisation of seven days. Temporary limitations of movements at knee and ankle was observed in most patients during first few months after plaster was removed. Shortening of leg amounting to 3", 2", 1½", 1" respectively was observed in four cases and one case had varus angulation of 30 degrees. Seven patients had pain over the fracture site for more than seven months.

Sarmiento (1970) treated 135 of fracture shaft tibia by a functional below knee brace and stated that the patient walked with full weight bearing after four weeks of injury. Average healing time was 14.1 weeks in both bone fracture leg and 16.8 weeks when fibula was intact. Average amount of shortening observed was 6.4 mm No rotation deformity was recognised at follow up but the ultimate degree of rotation of distal fragment was not measured accurately. Several minor pressure sores were encountered in the popliteal fossa.

TREATMENT OF TIBIAL FRACTURE BY PLATES AND SCREWS

Tibial shaft fractures treated by plate and screws have been used by various workers (Egger, 1945; White, 1953; Reynold, 1954 and Burwell, 1971).

Wade and Campbell (1958) reported discouraging results with the use of plates as compared to other form of surgery. According to them endosteum appeared to assume the sole responsibility for binding the fracture site, but fixed distraction and excess of foreign material made the use of plates hazardous.

Edwards (1965) stated that tibial fractures treated by open reduction and plate fixation both in closed and open fracture resulted in high rate of infection.

Muller et al (1965) treated tibial shaft fracture by compression plates. He reported encouraging results with dynamic compression plates and reported 93 percent results as good whereas only six percent complication

rate was found in closed group treated fracture of tibia.

Berkin and Marshal (1972) used three sided plate fixation for fractures of tibia. Two plates which were slotted fenestrated and gutter shaped were placed such that its linear margin would be in contact of bone on two sides and an Egger 's slotted plate placed along the third side. This assembly did not result into angulation. Ninety two tibial fractures were treated with above method. The overall results were very good in 72 cases, 11 were good and nine were satisfactory. There were six post operative wound infection. Delayed union occurred in 11 patients.

Linden and Larson (1979) in a randomized trial of 100 transplaced fractures treated conservatively or by A.O. plating found that complications in the A.O. group were more common. Their stay in the hospital was more, delayed union more frequent, but A.O. group healed faster with average time of 12 weeks as compared to the conservative group where healing time was 17 weeks whereas open fractures healed faster when treated conservatively.

Screw fixation was sometimes favoured for spiral or oblique fractures but while, Redly and Kerly (1953) Mamet and Maclean (1954) and Charnley (1961) claimed that this method is uncertain, since number of fractures redisplaced despite plaster immobilisation and there were more chances of non union.

TREATMENT OF TIBIAL FRACTURE BY EXTERNAL FIXATOR

Although open method offered exact opposition of fragments yet they bring potential danger of infection and delayed or non union. External fixation refers to a method of immobilisation of fracture with two or more pins attached to a rigid external metal frame or incorporated in plaster.

The first external fixation for the treatment of fractures was described by Molgaigne (1851). Parkhill (1897) described the use of two half pins above and two half pins below the fracture in long bone, externally joined by an indegenous clamp for fracture reduction and immobilisation.

Raoul Hoffmann of Switzerland (1938) developed a four plaster double frame external fixation device. He presented a series of articles decribing his method of external fixation from 1938 to 1954.

Karlstrom and Olerud (1975) treated 28 severe, open tibial fractures with stable external frame fixation by the vidal Adrey double frame method. The average time of limb kept in the frame was 4.9 months and then a P.T.B. cast was used. The mean time until full weight bearing without external support was 7.9 months.

Edward (1979) reported the study of 44 open tibial fractures. Seventy three percent of cases had bone loss or major comminution. After initial debridement double frame Hoffmann apparatus was applied and fracture reduced. Initial union was evident at four months, complete at seven

months. Thirty percent of cases developed pin tract infection which cleared off after removal of pins.

Traditional half frames are safe and provide excellent wound access but are not rigid enough to hold unstable fractures to deal with heavy limbs, or to permit early weight bearing (Schmidt and Poreback, 1983). They reported loss of reduction in 15 percent of their cases.

Bilateral frames rarely allow displacement but malunion occurred in upto 39 percent of cases (Kerimal, 1982). Refracture in eight percent (Lawyer and Lubbens, 1980) and pin tract infection in thirty percent (Edward et al, 1979).

Transfixation of ankle and foot dorsiflexors more distally may lead to permanent ankle stiffness. Emerson and Grabies (1983) followed up tibial fractures immobilized with bilateral frames and found that the most frequent complain was ankle and foot stiffness. Apart from neurovascular injuries and permanent joint stiffness pin tract infection have been the most serious limiting factor in the use of traditional unilateral or bilateral frames.

Clamsey et al (1979) treated 102 open tibial shaft fractures, 56 with cast immobilisation, 35 with internal fixation and seven with external fixation. Average time of healing was 19.5, 19 and 28 weeks respectively. Deep infection developed more in cases with internal fixation (11 percent) than in cases treated with cast immobilisation.

The favourable effect of pressure at fracture site was first described by Sir Hugo Owen Thomas of Liverpool and later by Sir Robert Jones, who used to expose and hammer the fracture site in cases of non-union to achieve union.

TREATMENT OF TIBIAL FRACTURE BY WALKING CAST

The technique of walking cast was first developed by Krause (1891) and later by Dollinger and Budapest(1893). They used to apply the unpadded plaster to treat fracture of leg, so that weight might be transmitted from tuberosity of tibia to bottom of plaster.

Egger (1949) demonstrated the effect of contact compression factor on the osteogenesis in surgical fractures. He described two forces acting at the fracture sites, the internal force exerted by the mass of the muscle especially in the voluntary contraction and external contact compression exerted by gravity and weight bearing. He concluded that :

1. Presence of contact compression factor stimulates the osteogenesis.
2. Excessive compression fails to stimulate osteogenesis.

Dehne (1961) treated fractured tibia by immobilization in a near skin tight cast with knee held in full extension and with immediate weight bearing. The average time of healing and return to work for all 207 patients was five months. In 86 percent of the patients the time for healing and mobilisation was between four and six months. In remaining 14 percent cases it varied from

two to four months.

Brown and Urban (1969) presented a series of 60 cases of fracture shaft tibia. After reduction a long leg cast was applied and early weight bearing was permitted He reported 100 percent union with average period of nineteen weeks. The overall shortening was nine months, angulation was less than ten degrees.

Gamble et al (1972) treated 100 fractures of tibia by early weight bearing in long leg cast and evaluated the result close to brown and Urban (1974). Brown concluded that the closed reduction and early weight bearing in long leg cast often concedes minor complication in favour of a predictably high union rate with no major complications and can be used for all types of tibial shaft fractures.

The advantage of ambulation were explained as the alternating contraction and relaxation of muscles of leg with improve circulation in the extremity and at fracture site. Venous return was enhanced, oedema was minimal and muscle tone maintained. All of which facilitated the mobilisation of the knee and ankle when the cast was removed.

A below knee cast moulded in a manner ressembling that of the patellar tendon bearing prosthesis stabilises the proximal fragment of tibial fracture. Weight bearing pressures are transmitted from the ground to the proximal end of the tibia virtually by passing the fracture site and suspending the fracture bone. The trangular moulding of the upper portion of the cast against the inverted pyramid of

proximal fragment prevents rotation and over riding of fragments. The indentation over the patellar tendon and the femoral condyles, appear to enhance the rotational stability.

Dunn et al (1973) in his study of 45 closed tibial shaft fractures, treated by PTB cast reported average healing time of 14.1 weeks. Non union occurred in two cases.

Sharma et al (1979) studied 258 fractures of tibia treated in below knee cast following toe to groin conventional treatment. The average time for union was 15 weeks. The fractures with intact fibula healed earlier than fractures of both bone leg.

This method of closed reduction and early weight bearing by either above knee or below knee cast is suitable for stable fractures or transverse fractures. Fractures that are oblique or comminuted and are unstable if subjected to above treatment may angulate or shorten unless some additional fixation is used.

To prevent loss of reduction and to avoid angulation or shortening Bohler advocated pin and plaster treatment as early as 1929. 259 fractures were treated by Coiswold and Holmer by pins incorporated in plaster. The results obtained were good. Anderson et al (1966) reported their experience with a method of closed treatment of fractures of tibia and fibula. They used Steinman pin through the tibia and closed reduction followed by plaster

application. They found certain advantages of this method over closed reduction in cases of unstable fractures of both bones of leg. In only 2.1 percent union was delayed and in 1.9 percent no union developed out of 128 fractures of the tibia and fibula treated by the above method.

Birotte and Joseph (1970) treated 75 fresh displaced fractures of tibia by percutaneous multiple pin fixation, short leg cast and immediate weight bearing reviewed 100 percent healing with an average period of healing between 16 to 20 weeks. They used four pins; two in proximal and two in distal fragments but segmental and comminuted fractures needed five or six pins. The mean time for healing was eighteen and half weeks. Oblique fractures healed slowly. There were no instances of non union or delayed union. Secondary, inflammatory reaction in about two pins occurred. Preserved knee motion was associated with early restored ankle and foot motion.

Trivedi and Patel (1978) used the method of insertion of stienman pins and incorporating them in a below knee total contact cast in 80 cases of fracture tibia and compared the results with above knee casts. The results showed that the average duration of plaster immobilisation was about same in both the series i.e. 4.2 months in below knee method and 4.5 months in above knee method. The occurrence of delayed union and failure rate were slightly lower in former method. The only complication was pin tract infection and loosening of the pin. Early

ambulation with full range of movements at knee minimised the quadriceps wasting.

TREATMENT OF FRACTURES OF FEMUR AND TIBIA BY INTRAMEDULLARY NAIL :

Clawson and Smith (1971) reported forty six closed intramedullary nailing of the femoral shaft done on forty five patients by a number of practicing orthopaedists and residents. Regardless of the severity of injury in the patients, 20 percent were fully weight bearing within one week and 73 percent within two months there was no infection or non-union. They recommended it as the treatment of choice for femoral shaft fractures in skeletally matured patients except those with severe comminution where bone to bone contact was insufficient to maintain the length.

Mc Master (1930) used fluted Sampson intra medullary rod in closed intramedullary nailing of fracture shaft femur in seventy nine patients. The average time to wheal chair status was two days post-operatively and partial weight bearing on crutches was accomplished within five days. The average time of hospital stay was 17.5 days. No patient developed non-union. Most patients were ambulatory without external support assistance at three months. Only three patients had a documented one inch shortening of the fractured femur.

Murti and Ring (1983) did closed medullary nailing of 61 fractures of the femoral shaft using the A.O. method in 59 patients. More than 50 percent of patient progressed to full weight bearing by the end of eight week. Knee flexion was full in 80 percent. There was no instance of non union and residual clinical deformity. Union of the fractures was radiologically confirmed in all cases. Some callus was seen as early as in the third week in one of the patients.

Chapman and Dewis (1980) gave a report of three cases of closed intramedullary bone grafting with nailing of fresh segmental fractures of the femoral diaphysis treated late. Keeping the patient on skeletal traction until the wound had healed and there was no evidence of infection. It was then that the fractures were stabilized. They found that abundant callus about both femoral fracture site was evident by fourth week. The limb lengths were equal and there was zero to 45 degrees of knee flexion at the knee joint. Traction was continued for six weeks even after the surgery.

King and Rush (1981) treated 112 traumatic fracture shaft femur by closed intramedullary nailing. There were sixty patients who began partial or full weight bearing within two weeks and thirty two within four weeks. Knee flexion to ninety degree was achieved by twelve patients within three weeks, by forty one patients within six weeks, and by thirty six patients within twelve weeks.

There was no non-union in this series. Radiological union was present in all fractures at six months and there was no death.

Leighton et al (1983) undertook a retrospective study of open versus closed intramedullary nailing of femoral shaft fractures. In the group of 65 patients treated by closed method had three failure of treatment and six major complications. Major complication included three malunion, one permanent pereneal nerve palsy and two intramedullary infections. Other group of 65 patients treated by open method had three minor and three major complications in form of deep vien thrombosis and shortening of upto three cm. Satisfactory results in closed nailing were upto 92 percent while in open nailing upto 97 percent.

Stewart and Phillips (1986) treated 23 patients of fracture shaft femur with closed medullary fluted rod. They found that the average time to walk with support was four days. Most of the patients were discharged from the hospital by fourteen days. Average time to walk without support was four weeks. Average time to return to work was fourteen weeks and the average time for the union of fracture was fifteen weeks.

Wilson et al (1987) treated fourteen patients of fracture shaft femur by closed interlocking medullary nail. They stated that average time of patient's stay in the hospital was 27 days. Partial weight bearing was

allowed within first three week of surgery and full weight bearing was achieved within eight weeks. Radiological evidence of healing was evident on an average of 13 weeks and return to work in most cases was within 14 weeks.

Lambotte (1913); Grooves (1918) and Rush and Rush (1937) used some forms of nail for intramedullary fixation of tibial fractures. Kuntscher (1958) used the improved nail and his method gained popularity. Introduction of strong intramedullary nail combined with the principle of reaming out the medullary canal and the development of image intensifier have recovered interest in closed nailing. Lottes (1952) and Bohler (1965) reported encouraging results with such technique. Anderson (1971), solhein (1960), Watson Jones (1953) have not favoured its use and observed that there was no real merit in the attempt to secure fixation of fractures by intramedullary nailing.

Lottes (1952) evaluated the results of 176 fractures of the tibial shaft treated by nailing, plating and plaster immobilisation. The average healing time was six months, 11.8 months and 8.4 months respectively. Incidence of non union was 23.7 percent with plating, 10 percent with conservative treatment and none with nailing. As regards the deformity, there was varus or valgus angulation of three degree or more in 19.6 percent cases of conservative treatment, 5.7 percent in closed nailing and 4.3 percent in plate fixation. For the three groups shortening of over 6 cm was in 19.6 percent, 1.9

percent and 4.3 percent of the cases in that order.

Lottes (1954) reported 300 cases of tibial shaft fractures treated by the closed intramedullary nailing. He used Lottes nail. It was necessary to expose the fracture site in only three out of 300 cases all in fresh fractures, because of failure to obtain reduction by closed method. In fresh fractures of tibia with intact fibula, the fibula was osteotomised after the nailing had been completed to allow impaction and weight bearing.

Alder et al (1962) reported that osteomyelitis developed in twenty percent cases of open fracture treated by medullary nailing and only in 2.2 percent of similar fractures treated without internal fixation. They also stated that Kuntscher nailing cannot be used in comminuted fractures and also in patients below fourteen years of age, because of fear of epiphyseal damage.

Alms (1962) treated a total of 50 fractures of tibial shaft by closed intramedullary nailing for which no external splint was used and the patient allowed to walk as soon as the wound healed. The average period of absence from work for the patient was eleven weeks. There was no case of sepsis or non union.

Caladias (1964) and Dankwardtt (1969) described that the nutrient artery is destroyed and endosteum and bone marrow is almost completely removed because of reaming and nailing and so more chances of delayed or non union. Endosteal callus formation is scarce. There are chances

of fat embolism following reaming of tibia.

Nicoll (1964) in his survey of 705 cases of fresh tibial shaft fractures of which 674 were treated conservatively and 31 were treated by primary intramedullary nailing or plating. In his opinion "Internal fixation actually delays union unless it is absolutely rigid and this is never the case with intramedullary nailing". He did agree that practically all fractures can be stabilised and patient can become ambulant in plaster within a desired time but internal fixation can be justified on following grounds that it reduces the incidence of functionally significant deformity and joint stiffness. It significantly lowers the risk of delayed and non union, that the advantages so claimed are great enough to out-weigh the additional hazards of surgery, which in a subcutaneous bone like tibia can be disastrous.

Zuckman and Maurer (1969) reported 36 cases of two level fractures of tibia treated by blind nailing of which 17 patients had closed fractures. Primary bone union in good position was obtained in 15 cases and aseptic union was found in 0.2 percent . No case had malunion, union with sepsis or septic nonunion. They concluded that both the fractures upper and lower had the same potential for union. In these cases walking was started with full weight bearing in an average time of three to four months and it decreases the rate of non union and infection as compared with other type of fixation devices.

Hamza et al (1971) reported 50 patients with fracture tibia - 28 closed and 22 open treated by intramedullary nailing. Nineteen patients had closed nailing and remaining underwent open nailing. Average time for clinical union was three months. Radiological union was obtained at an average of four months. Average time interval between injury and return to work was 4.5 months. Patients who had developed non union during treatment by other method can obtain union expeditiously after reaming and inserting large size nail.

Olerud and Karlstrom (1972) did secondary intramedullary nailing of tibial fractures. They took thirteen patients who had already been treated with compression plating but due to poor compression achieved they underwent secondary intramedullary nailing after reaming of medullary canal; with regard stability delayed intramedullary nailing has an important advantage namely the endosteal callus which gives nail a firm grip in fracture of lower and upper end of tibia. Out of 13 cases only one had infection which considerably delayed the healing of fracture. The final results were excellent or good in 87 percent of cases.

Smith (1974) compared the results of early and delayed internal fixation in the treatment of fractures shaft of tibia. He observed that average healing time was 26 weeks in cases of early internal fixation and eighteen weeks in delayed internal fixation. He thus confirmed

that in except mild fractures early internal fixation would always increase the time of healing and incidence of complications.

Sharma et al (1978) treated 45 cases of fracture shaft tibia by intramedullary 'V nailing'. Clinical union was evident by ten to fifteen weeks. Complications developed like deep wound infection in 17.2 percent and bending of nail in 7.4 percent. Patient was allowed to walk with the help of crutches after removal of stitches and was allowed to walk with weight bearing after 6 weeks. The hospital stay was from 11 to 20 days.

Groose, Kempf (1982) used interlocking tibial nail which have holes through their proximal and distal ends and are used for fractures of proximal or distal third of tibia, segmental fractures and fractures with significant comminution.

Mayer et al (1985) treated 51 severe fractures of the tibial shaft with multiple intramedullary Enders nail. Forty one fractures united in less than four months and eight within four to eight months. Only two were not united even after eight months.

Lawrence and Kenneth (1986) treated 112 fractures of the tibia by manipulation reduction, reaming of medullary canal and fixation of fragments with an intramedullary nail either ASIF/AO or interlocking nail.

Follow up evaluation was performed in 100 fractures. The average time of union of fracture was 19 weeks. Two patients had delayed union. Deep sepsis developed in seven percent and superficial in two percent.

Rao and Shahne (1986) treated 103 tibial shaft fractures by closed intramedullary V nailing without image intensifier. Patients were allowed to bear full weight in patellar tendon bearing cast. By twelve weeks 91 fractures had united while at 18 weeks only three had non union. Four patients needed re-operation for sequestrectomy and delayed union.

MATERIAL AND METHODS

MATERIAL AND METHODS

The proposed study "Closed Intramedullary Nailing In the Treatment of Fresh Simple Fracture of Shaft of Tibia" was conducted in the department of Orthopaedics at M.L.B. Medical College and associated Hospitals, Jhansi through the concerned outdoor patient department and the casuality department. A total of 14 cases of fracture of tibial shaft were treated with the above said method from July, 1987 to June, 1988.

All the adults patient with fracture of tibial shaft attending the orthopaedic department, irrespective of sex were included in the study.

CRITERIA FOR SELECTION OF CASES

All the patients with fresh simple fracture or Grade I type of compound injury and had passed the age of skeletal maturity were selected for the study.

In our study contraindications for closed tibial nailing were as follows :

1. Children.
2. Compound injury (except Grade I) punctured wound.
3. Unsuitable condition of neighbouring skin abrasions, blebs, burns etc.
4. Type of fracture :
   a. Too near to either ends of bone.
   b. Gross comminution.
   c. Long oblique and long spiral fractures.
   d. Injury more than three weeks old.

MANAGEMENT OF FRACTURE

As soon as the patient was admitted, he was given first aid management in form of plaster of paris above knee slab along with analgesics and anti-inflammatory drugs.

Cases who were fit for nailing underwent following pre-operative evaluation.

1. General assessment of vital parameters.
   a. General condition of patients.
   b. Blood pressure.
   c. Pulse.
   d. Routine examination of other systems.
2. Local examination of skin at and away from fracture site including examination for associated neurovascular involvement.
3. Radiological examination done by placing K-nail gauge and metallic measuring scale by the side of the effected limb.
   a. For the type and site of the fracture.
   b. Size and diameter of the nail required.
4. Investigations :
   a. Routine.
   b. Specific.

After the above procedures were done the datas were collected and recorded as follows :

Case No.

MRD No.

Name of the patient : Address :

Age/Sex : Occupation :

Date of admission

Brief History :

Date of injury :

Mode of injury :

Any other associated injury :

Fracture

Side : Right/Left/Both

Site : Proximal/Middle/Distal

Bone involved : Tibia/Tibia and fibula

Nature : Simple/Grade I(Punctured wound)

Comminution : Present/not present

Fracture line : Transverse/Short oblique/short spiral.

Date of first aid treatment :
and POP slab application :

APPARATUS AND INSTRUMENTS

Apart from the general set of instruments, following are specially required.

1. A metal ruler which could be autoclaved and cast shadow on X-ray as to measure the length of the nail required.
2. Kuntscher nail gauge to assess the diameter of the nail per operatively and the diameter of medullary canal radiologically.
3. Kuntscher medullary nails of various size and diameter.
4. Femoral awl.
5. Guide wires.

INSTRUMENTS

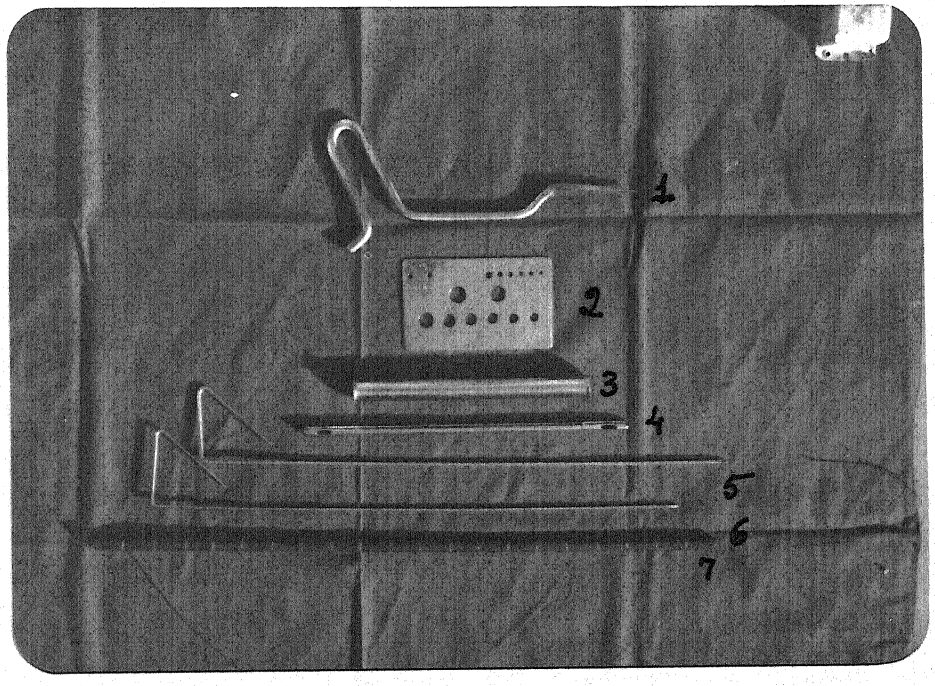


Fig. 1 : **Special required instruments :**

1. Femoral bone awl.
2. Kuntscher nail Gauge.
3. Kuntscher nail impactor.
4. Kuntscher Cloverleaf nail.

5&6. Guide wires.

7. Calibrated metal ruler.

6. Mallet.
7. Driving punch for the nail.
8. K-nail extractor with hook.
9. Hack-saw.
10. Straight chisels and gauges.

PRE-OPERATIVE ASSESSMENT OF THE SIZE OF NAIL

A. Length of Nail

A metallic rod of 16" length was carved deep enough all around its circumference at a spacing of 1" so as to cast shadow in the radiogram. This served as a metal ruler to measure the length of the nail required pre-operatively.

Splintage was removed on X-ray table and the metal ruler awas strapped by the side of the limb parallel to the bone in such a way that its shadow would not super-impose upon that of underlying bone and the magnification of the ruler would be same as that of the bone. In anteroposterior view ruler was strapped laterally and in lateral view anteriorly or posteriorly as per convenience. By seeing the X-ray required length of the nail could be readily calculated.

B. Diameter of Nail

Kuntscher nail gauze which had caliberated holes ranging from six mm diameter with an increment of one mm each upto 14 mm was placed by the side of limb in such a way to give the same magnification of medullary canal as that of caliberated holes. The holes were matched with

the narrowest diameter of medullary canal on roentegeno gram to give the required width of nail

OPERATIVE PROCEDURE

After appropriate anaesthesia was given the patient was laid supine on the ordinary operation table. The part was painted and drapped from lower thigh to just above the ankle.

Knee of the injured side was flexed to about 135 degrees, about two centimeters vertical incision was given just medial to the ligamentum patellae. The retro-patellar pad of fat was exposed and the deep infrapatellar bursa opened taking care not to open the knee joint.

A femoral awl was passed through the skin incision and displacing the ligamentum patellae laterally and striking the tibial plateau over anterior end of inter-condylar ridge about two centimeters behind the anterior border of tibia. This site is extra articular. Awl was thrust further along the long axis of proximal fragment of tibia thus making the pilot track for the guide wire.

Guide wire was passed down the pilot track just short of the fracture site.

Limb was allowed to suspend vertically down by the side of the table with knee resting at the edge. Closed manipulation of fracture done and reduction was achieved and held in position.

Guide wire was passed further by the assistant to engage the medullary canal of the distal fragment.

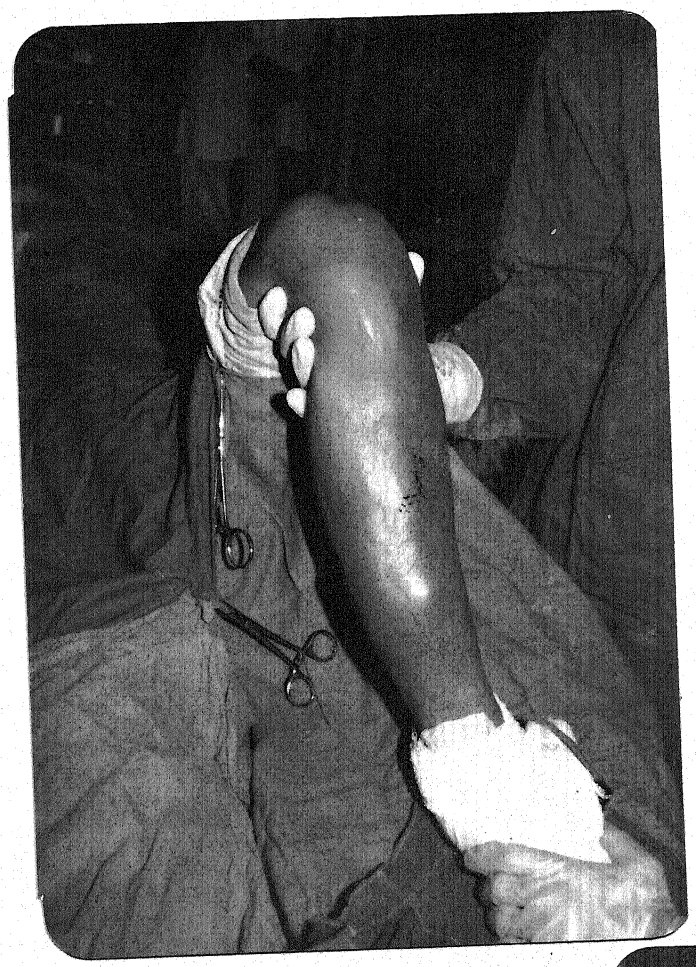


Fig. 2a : Part painted and draped.

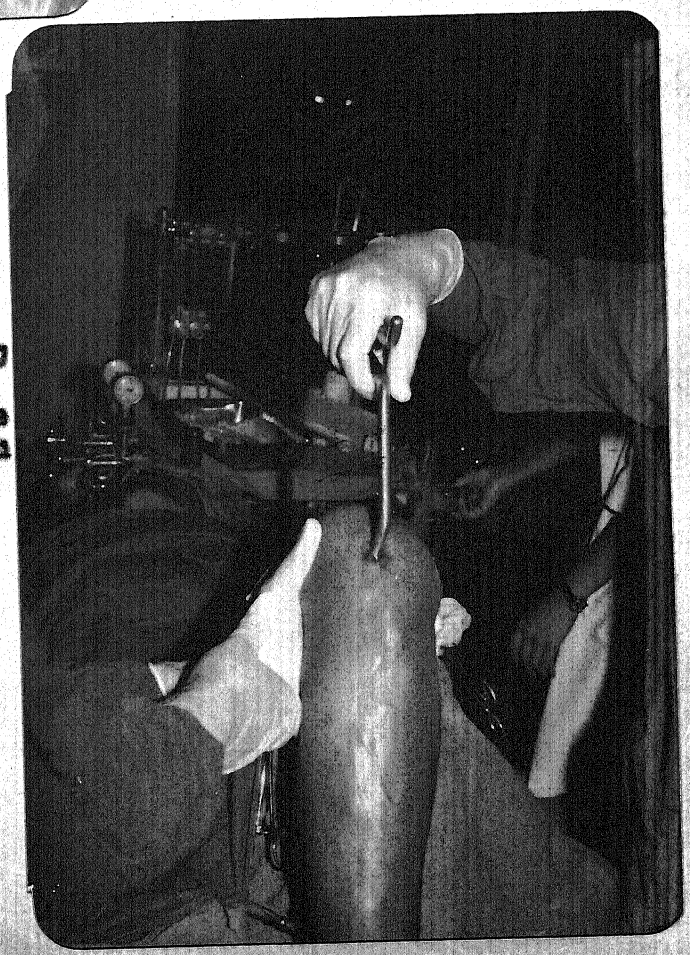


Fig. 2b : Pilot track being made through prespinal surface of tibial plateau

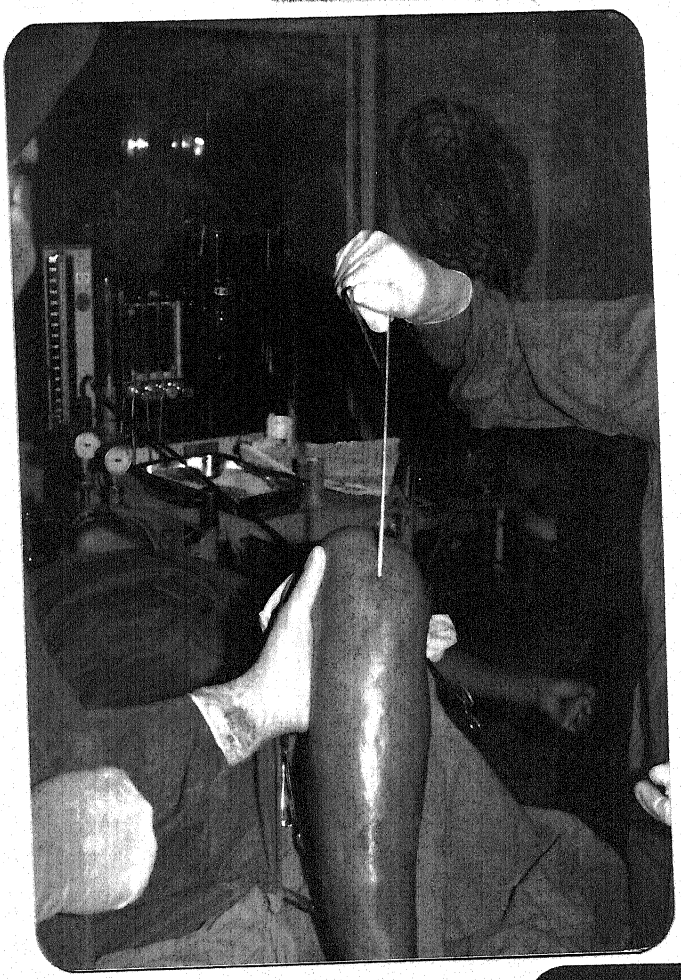


Fig. 2c :

Guide wire being passed in the proximal fragment of tibia.

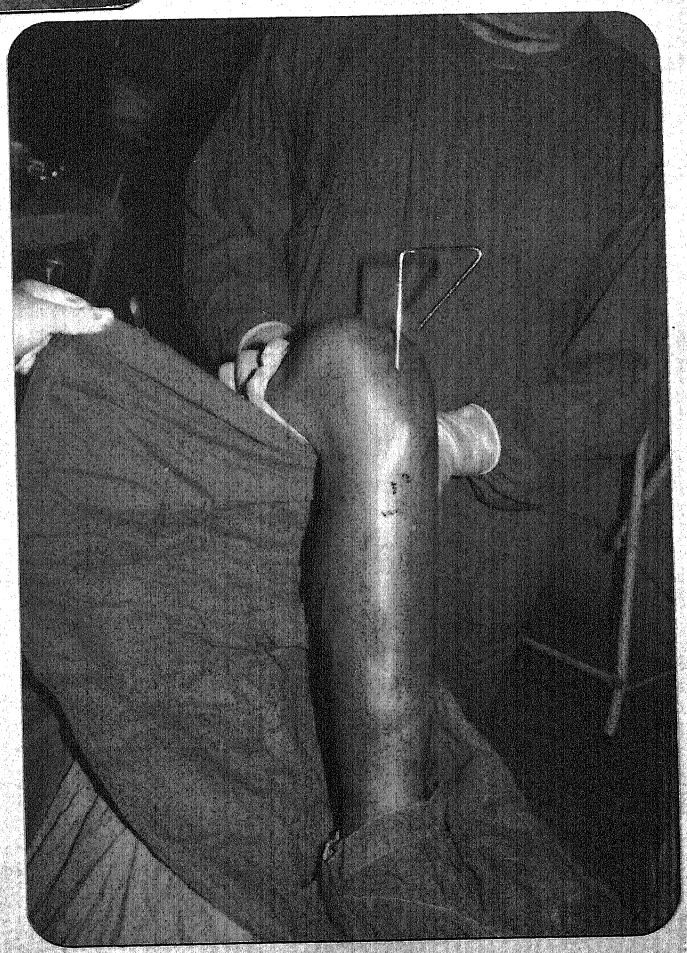


Fig. 2d :

Guide wire has been passed in the distal fragment after manipulative reduction had been achieved.

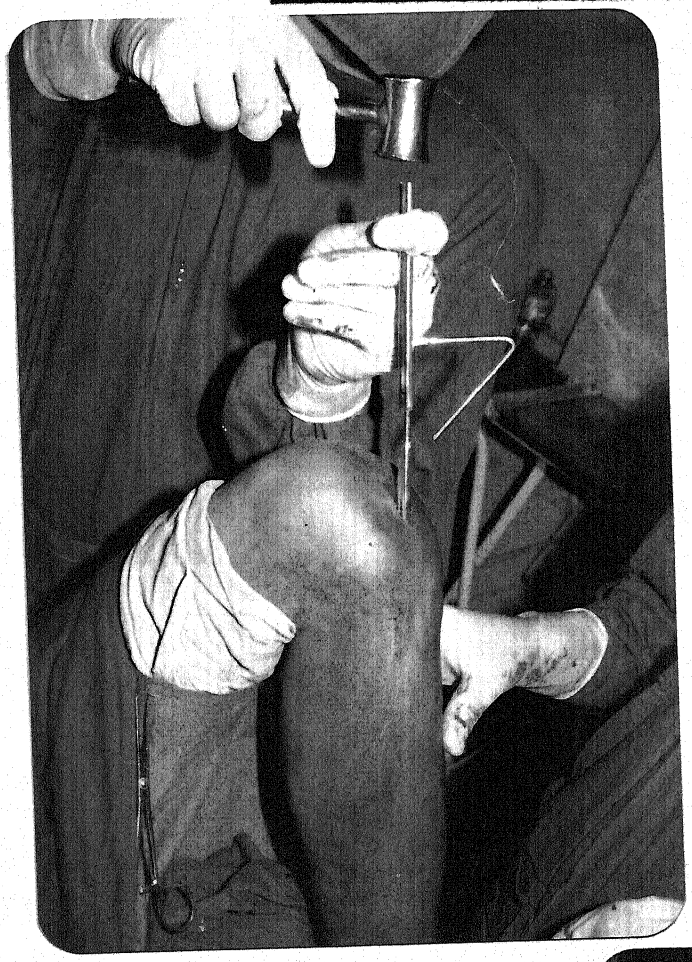


Fig. 2e :

K-nail being hammered home with the help of another Kuntscher nail.



Fig. 2f : Wound closed.

Knee was again flexed at 135 degrees. Kuntscher clover leaf nail of appropriate size threaded over the guide wire and hammered home taking care of patella and second toe to lie in the same line.

Guide wire was withdrawn and wound was stitched back in single layer and dressed.

Long leg above knee plaster of paris slab was given.

POST-OPERATIVE MANAGEMENT

Post operative check X-rays were taken and if there was any distraction it was corrected at the earliest by giving short acting general anaesthesia in the operation theatre and applying punches at the heel with an assistant giving counter pressure by holding the knee of the effected side. If the nail was found to lie out of the distal fragment and had passed in the soft tissue it was extracted and reinserted by the same procedure mentioned above.

Stitches were removed after 10 to 14 days and long leg above knee plaster cast or patellar tendon bearing cast was given depending upon the type of fracture and the fixation of nail. Usually patient was made to walk with the help of walker with plaster incorporated. Unassisted weight bearing became possible within one to two weeks.

FOLLOW UP

Patients were discharged at a suitable time after operation with detailed instructions regarding do's and dont's and were followed up clinically and radiologically at three, six, twelve and twenty weeks interval.

All relevant datas were filed and tabulated in the following way so as to reach the final result.

a. Wound Scar : Healthy linear scar/unhealthy scar.

b. Callus : Palpable Radiologically

Weeks : 3

6

12

20

c. Movements of knee joint measured in degrees.

	Knee Joint		Ankle Joint	
	Flexion	Extension	Plantar flexion	Dorsiflexion
3 weeks				
6 weeks				
12 weeks				
20 weeks				

d. Form and duration(in weeks) of external splintage

i. Long leg dorsal slab :

ii. Long leg plaster :

iii. Long leg walking plaster :

iv. Patellar tendon bearing :

v. Assisted weight bearing :

vi. Unassisted weight bearing:

vii.. Unprotected weight bearing:

viii. Return to employment in weeks:

Fractures were called united when the fracture line was not clearly visible and the traversing trabeculae at the fracture site had appeared.

EVALUATION OF RESULTS

The results were evaluated as excellent, good or poor on the basis of various parameters given below.

	Result		
	Excellent	Good	Poor
Symptoms			
Squatting after a month of removal of external splintage	Normal	With some difficulty	Unable to squat
Pain at fracture site after 3 weeks	None or slight	Moderate	Severe
Difficulty in walking	None	Mild	Severe limp.
Work and activity	Unchanged	Slightly compromised	Unable to do work
Signs			
Skin condition including stitch line.	Healthy	Superficial infection	Deep infection
Deformity	None	Slight	Easily noticeable
Shortening	None	< 1 cm	> 1 cm
Loss of knee movement	0 or $< 10^{\circ}$	$10-20^{\circ}$	$> 20^{\circ}$
Loss of ankle movements	0 or $< 5^{\circ}$	5 to 10°	$> 10^{\circ}$
Radiology			
Formation of bridging callus	3 weeks	4 to 5 weeks	5 weeks
Gradual disappearance of fracture line	6 weeks	7 to 8 weeks	> 8 weeks.

OBSERVATIONS

OBSERVATIONS

In our study a total of 14 cases of fresh fractured tibia were treated by closed intramedullary nailing in the department of Orthopaedics, M.L.B. Medical College, Jhansi.

Age Distribution

Age-wise breakup of patients is shown in table I. Age of the patients varied from 18 years to 57 years. Maximum number of cases about 86 percent belonged to age group ranging from 18 to 37 years (The youngest patient to undergo closed nailing was 18 years).

Table I

Agr group (years)	No.of cases	Percentage
18 - 27	7	50
28 - 37	5	36
38 - 47	1	7
48 - 57	1	7
Total	14	100

Sex Incidence

The males outnumbered the females as out of 14 cases, 12 cases were male and two as female (Table II).

Table II

Sex	No.of cases	Percentage
Male	12	86
Female	2	14
Total	14	100

Occupation of the Patient

According to the occupation patients were divided into light workers (House wives, students, retired old man) and heavy workers (Farmers and labourers). Out of 14 cases both the categories carried seven cases each. (Table III).

Table III

Occupation	No.of cases	Percentage
Light worker	7	50
Heavy worker	7	50
Total	14	100

Mode of Injury

In eight cases (57%) the mode of injury was a fall from a height or fall while running whereas road side accident contributed 43 percent of the total injury and no case was reported due to industrial accident.

Table IV

Mode of Injury	No.of cases	Percentage
Fall	8	57
Road side accident	6	43
Industrial accident	-	-
Total	14	100

Side Involved

Out of 14 cases six(43%) cases had fracture of left tibia and eight (57%) had fracture of right tibia (Table V).

Table V

Side Involved	No.of cases	Percentage
Left	6	43
Right	8	57
Total	14	100

Condition of fibula

Out of 14 cases 11 patients had associated fracture of fibula of the same side while three patients (21%) had intact fibula.

Table VI

Condition of fibula	No.of cases	Percentage
Fractured	11	79
Intact	3	21
Total	14	100

Level of Fracture

Majority of the cases had fracture of the middle one third (57%) followed by the fracture at the junction of middle and distal one third (29%) followed by fracture of the proximal one third (14%) (Table VII).

Table VII

Level of fracture	No.of cases	Percentage
Proximal one third	2	14
Middle one third	8	57
Junction of middle and distal third	4	29
Total	14	100

Nature of Fracture

Out of 14 cases 50 percent of patients had closed type of fracture and remaining 50 percent of patients had open fracture of Grade I type injury or punctured wound (Table VIII).

Table VIII

Nature of Fracture	No.of cases	Percentage
Closed fracture(simple)	7	50
Open fracture (Grade I)	7	50
Total	14	100

Type of Fracture

Majority of the patients (43 percent) under taken in this study had comminution while short spiral fracture (7%) was least to come across. Amongst the

comminuted fractures there were two cases who had significant and four cases had insignificant comminution.

Table IX

Type of Fracture	No.of cases	Percentage
Transverse	3	21
Short oblique	4	29
Short spiral	1	7
Comminuted :		
- Significant	2	14
- Insignificant	4	29
Total	14	100

Time Interval between Injury and Nailing

In about 57 percent of cases nailing was done between one to two weeks. The shortest time interval between injury and nailing was one day and longest was 21 days (Table X).

Table X

Interval (days)	No. of cases	Percentage
0 - 7	5	36
8 - 14	8	57
15 - 21	1	7
Total	14	100

Per-operative Complications

In our study of fracture tibia taken for closed nailing there were two cases (14%) in which satisfactory

closed reduction was not achieved and they underwent open reduction. Distraction at the fracture site occurred in two cases (14%) which was corrected in the next sitting. In one cases (7%) the nail left the guide wire at the fracture site and got encarcerated in the cortex of the distal fragment and in one case (7%) the nail did not engage the distal fragment. There was no case in which there was significant protrusion of nail beyond the site of introduction. Not a single patient had stuck nail. (Table XI).

Table XI

Per-operative Complication	No.of cases	Percentage
Failed closed reduction	2	14
Distraction at fracture site	2	14
Nail leaving the guide wire at the fracture site	1	7
Nail not engaging the distal fragment	1	7
Stuck nail	-	-
Additional comminution at fracture site	-	-
Significant protrusion of nail beyond the site of introduction.	-	-

Diameter of K-nail

In most of the cases nine millimeter diameter nail was passed in the medullary canal whereas in seven percent of cases each accepted seven and eight millimeter diameter nail (Table XII).

Table XII

Diameter of nail(mm)	No.of cases	Percentage
7	1	7
8	1	7
9	8	57
10	4	29

Operative time for closed nailing tibia

Operative time required for successful closed nailing ranged from 20 minutes to 50 minutes at an average of 35 minutes. The total time taken was right from giving the skin incision to the closure of skin.

Table XIII

Time required(min)		Average
Minimum	Maximum	
20	50	35

Duration of Hospital Stay

Out of 12 cases of successful closed nailing eight cases (66%) had hospital stay of two weeks whereas maximum duration of stay of three and four weeks were reported in two cases each (Table XIV).

Table XIV

Hospital stay in weeks	No.of cases	Percentage
1	-	-
2	8	66
3	2	17
4	2	17
Total	12	100

Incidence of post-operative complications in successful closed nailing

Out of all the successful closed nailing only one case (8%) had limitation of dorsiflexion of ankle joint which was gradually being corrected with repeated physiotherapy till he visited the hospital last. No patient had superficial wound infection, shortening of limb, rotational malalignment, angulation, migration of nail or marked joint stiffness of knee joint. All except one mentioned above did not have marked joint stiffness of ankle joint (Table XV).

Table XV

Post-operative complications	No.of cases	Percentage
Superficial wound infection	-	-
Shortening of limb(1 cm or more)	-	-
Rotational malalignment(10^{0} or more)	-	-
Angulation	-	-
Marked knee joint stiffness :		
Flexion	-	-
Extension	-	-
Marked joint stiffness of ankle:		
Dorsiflexion	1	8
Plantar flexion	-	-
Migration of nail	-	-

CASE NO. 1

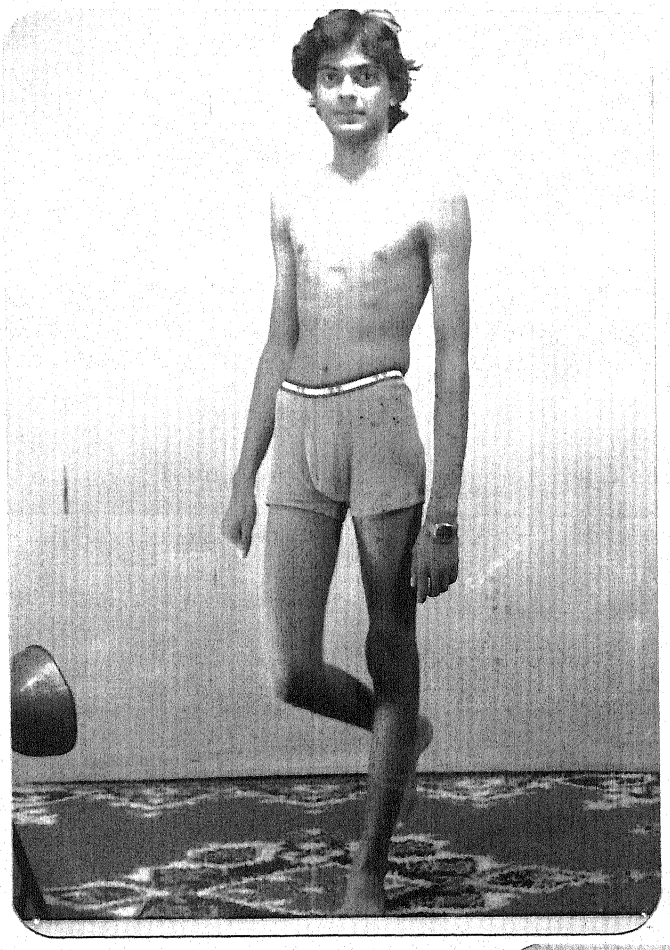


Fig. 3a :

Unprotected weight bearing after six weeks of closed nailing.

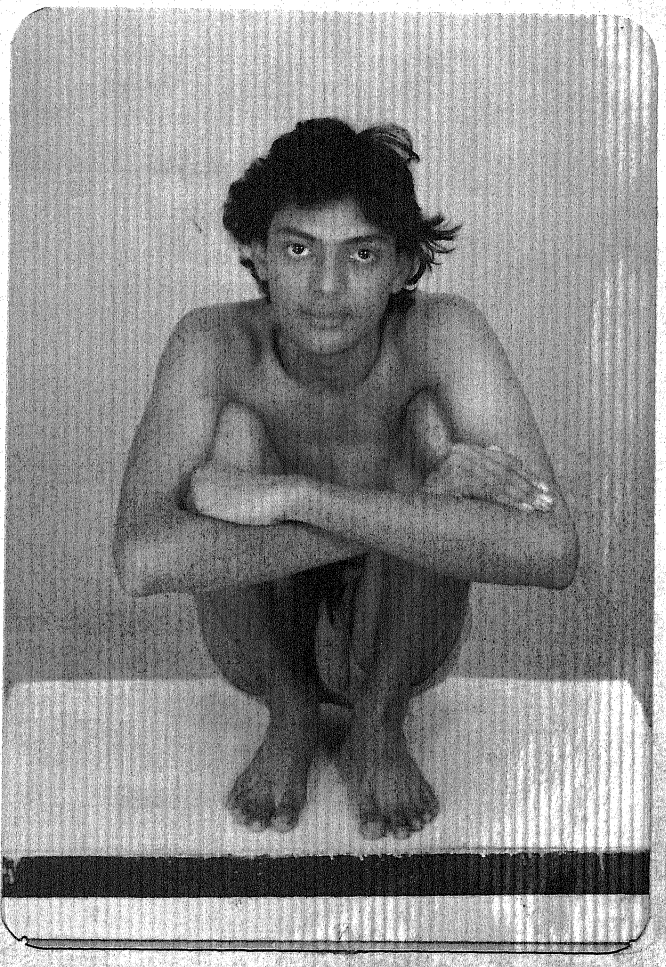


Fig. 3b :

Patient squating 6 weeks after closed nailing.

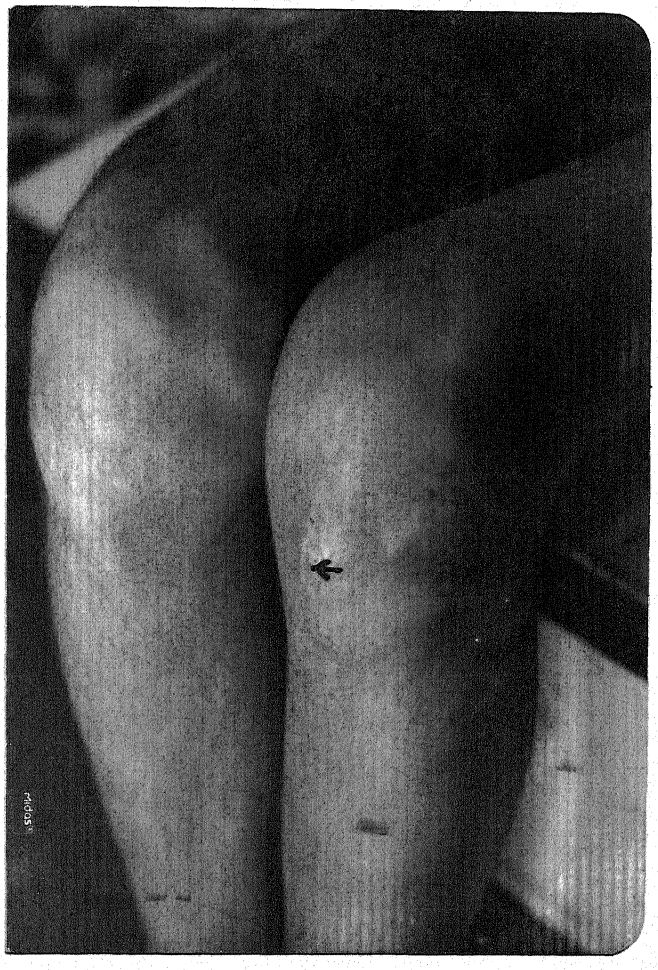


Fig. 3c : Inconspicuous operative Scar (Shown by an arrow)

of fracture line was seen. Most of the patients became pain free at the fracture site by 4 weeks but patient with intact fibula had pain even after six weeks of nailing (Table XVII).

Table XVII

Average duration of start of bridging callus formation (weeks)	Average duration of partial obliteration of fracture line	Average duration of painless state at the fracture site
3	6	4

Duration between injury and return to work in cases of successful closed nailing.

In all there were 10 patients who were working men. Average duration between injury and return to work was eighteen weeks.

Table XVIII

No. of working patients	Time Interval (weeks)
10	18

Duration of Follow-up

Maximum duration of 52 weeks follow up was reported in one case with a shortest duration of seven weeks follow up reported in the patient who underwent nailing shortly before the completion of the study. The average follow up reported was 24 weeks (Table XIX).

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Duration between injury and return to work in cases of successful closed nailing.

In all there were 10 patients who were working men. Average duration between injury and return to work was eighteen weeks.

Table XVIII

No. of working patients	Time Interval(weeks)
10	18

Duration of Follow-up

Maximum duration of 32 weeks follow up was reported in one case with a shortest duration of seven weeks follow up reported in the patient who underwent nailing shortly before the completion of the study. The average follow up reported was 24 weeks(Table XIX).

Table XIX

No. of cases	Follow up (Weeks)		
	Longest	Shortest	Average
14	52	7	24

Overall end result of successful Closed Nailing of Tibia

Out of 14 cases 12 cases underwent closed nailing and in remaining two cases closed reduction was not possible and hence open reduction and internal fixation was done. Amongst the fracture which underwent closed nailing 11 patients had excellent result. One patient had good result as six months after nailing he had more than 10 degree loss of dorsiflexion of the ankle joint (Table XX).

Table XX

Total No.of cases	No. of cases		Overall result of closed nailing		
	Open Reduction was done	Closed Nailing was done	Excellent	Good	Poor
14	2	12	11	1	-

CASE No. 1



Fig. 4a :

Pre-operative Skiagram along with K-nail gauze

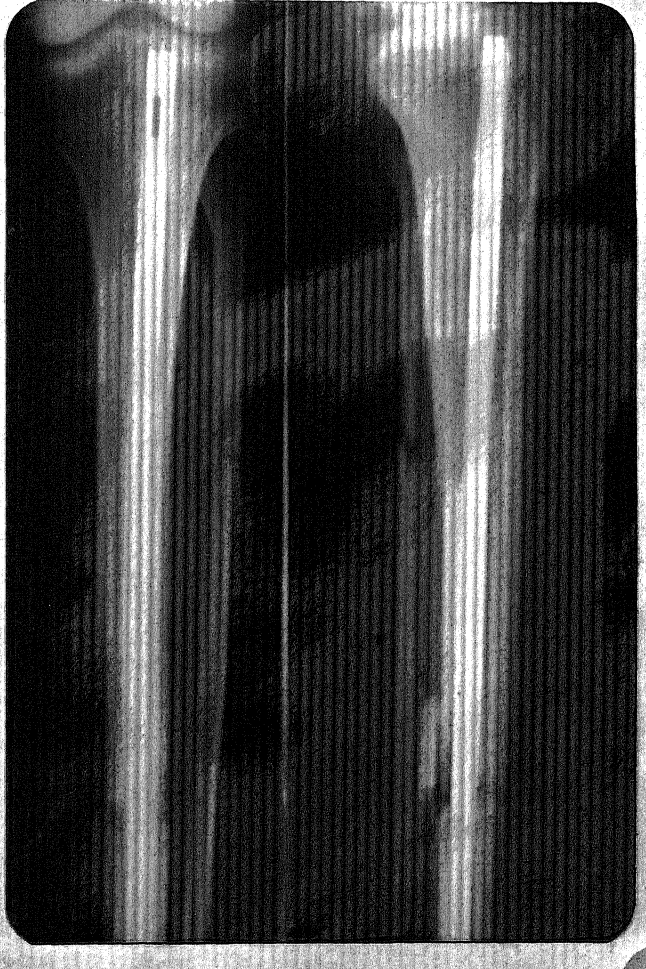


Fig. 4b :

Three weeks after closed nailing. Comminuted fragment has fallen in line.

CASE No. 1

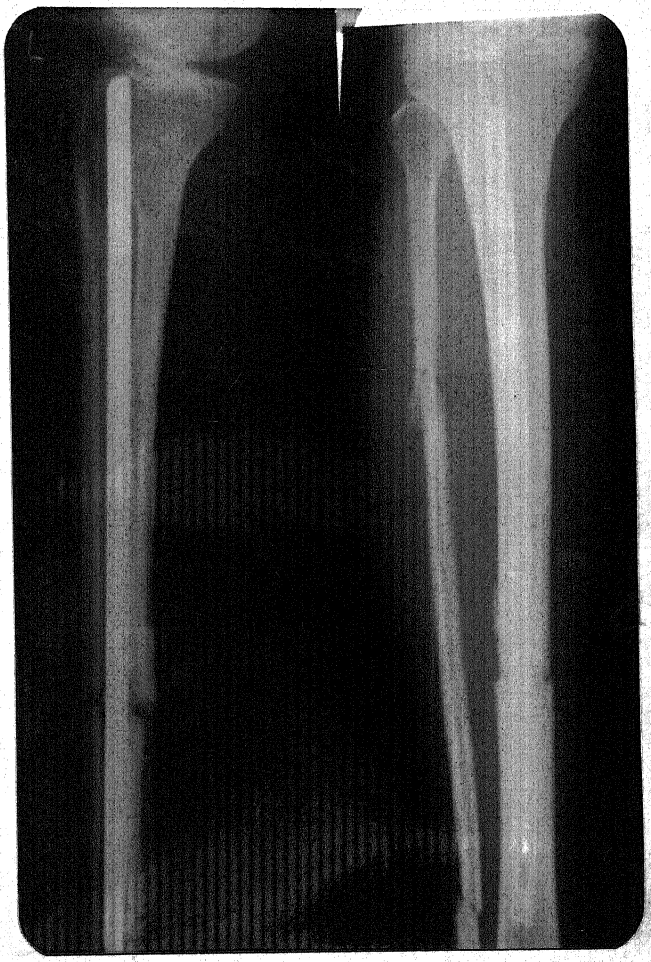


Fig. 4c :

Six weeks after closed nailing. Comminuted fragment has united with the proximal fragment.

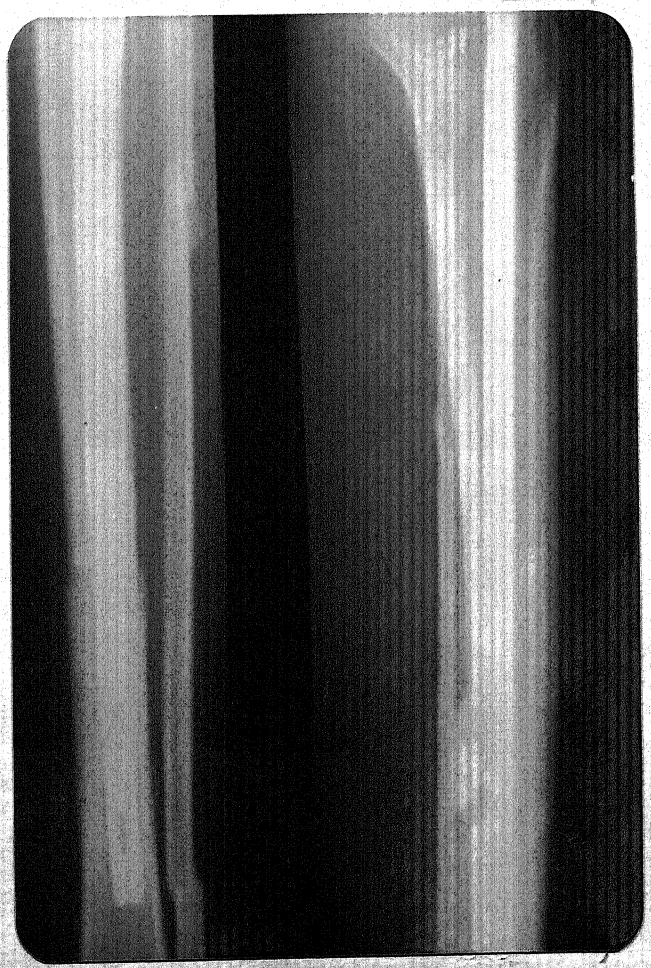


Fig. 4d :

Twenty weeks after closed nailing. Fracture line no more visible.

SKIAGRAM OF COMPLICATIONS MET

CASE No. 12



Fig. 5a :

Nail not engaging the distal fragment a likely complication with fibula intact.



Fig. 5b :

Corrected by open method.

SKIAGRAM OF COMPLICATION MET

CASE No. 14



Fig. 5c : Nail getting incarcerated in the cortex of distal fragment.

DISCUSSION

DISCUSSION

Fracture of both bones leg have long been considered difficult problem. Most series of reported non-union list the tibia being the most common site of non-union of all diaphyseal fractures. The old aged method of above knee immobilisation in plaster cast has many complications such as :

a. Increase time of hospitalisation, convalescence or both.
b. Stiffness of the joint and decrease range of joint movements.
c. Increase rate of non-union, delayed union and malunion.

The alternative method of open reduction and internal fixation though results in good alignment and fixation of fractured fragment is not free from many disadvantages and complications such as :

1. Vascularisation of fractured area is impaired as periosteum is further damaged and fracture haematoma drains out which may result in deficient nutrition of osteogenic calls and subsequent delayed union and non union.
2. Increased rate of infection.
3. It inflict surgical trauma.

A compromise between open reduction and conventional method of treatment appears to be more logical. Under these circumstances Closed method of nailing for the

fractured tibia was proposed. It has certain advantages such as :

a. It inflicts minimal surgical trauma.

b. Fracture haematoma is least interfered with.

c. Cancellous bone from within the medullary canal is driven into fracture haematoma thus conferring it with considerable osteogenic potential.

d. Periosteal blood supply is not further disturbed.

e. Infection is low or practically nil.

This technique of closed nailing is in use at various centers for quite some time particularly after the availability of image intensifier. Our being a poor country the facility of image intensifier is available only at few places. Yet the advantages outlined above form a strong case in favour of close nailing. Therefore we have endeavoured to simplify and perfect the technique of closed intramedullary nailing in simple fresh cases of fractured tibia doing away with the paraphernalia of elaborate arrangements and costly gadgets. Our efforts are mainly directed to devise such a method which may be used extensively without the use of image intensifier and is simple to achieve.

Hence we relied upon the clinical judgement of fracture reduction, positioning of guide wire and ultimately of the nail. In only one case the nail failed to pass in the distal fragment as the fracture stability was misjudged because of intact fibula. It was discovered on X-ray and was corrected in the next sitting.

The maximum number of cases (50 percent) ranged between 18 to 27 years of age and the males (86 percent) outnumbered females (14 percent) which should be due to their more active outdoor life making them more prone to trauma.

Majority of the cases had fracture of the middle third of tibia followed by the fracture at the junction of middle and distal one third and the least number of cases (14 percent) had fracture of the upper third. The low incidence of fracture in the upper third is probably because of more soft tissue covering of bone in upper part than in middle and lower region. Tibia being subcutaneous in most of the length had high incidence of open (Grade I) fractures (50 percent) than any other long bone.

Comminuted (43 percent) and oblique (23 percent) fractures were more commonly seen in our study which may be because of the position of tibia between two hinge joints so that twisting forces make it more vulnerable to the above type of fractures.

Lottes et al (1952) in his series of 216 tibial shaft fractures treated 102 cases by closed nailing and rest by plating or conservative method. They introduced the nail from the prespinal surface of the tibial plateau keeping the leg horizontal. The same position of limb was used by Lottes (1954); Alms (1962); Zuckman and Maurer (1969); Hamza et al (1971); and Smith (1974). In all our patients the site of introduction of nail was the same as above but we kept the limb acutely flexed to about 135°

while introducing the guide wire and about right angle, suspended by the side of table while achieving reduction and negotiating the guide wire in the distal fragment. The knee was again flexed to about 135° making the leg almost vertical and placing the sole over the operation table while the nail was threaded over the guide wire and hammered home.

Lottes et al (1952) used Lotte's triflanged nail without using any guide wire. Alms, Zuckman and Maurer (1969) and Hamza et al (1971) used Kuntscher clover leaf nail bent 10 to 20 degree anteriorly near the upper end for easier extraction. In all of our cases we used Kuntscher clover leaf nail. The tip of the guide wire was made blunt so that it may not perforate the posterior cortex of proximal tibial fragment and moreover the soft tissues and vessels after the guide wire had passed through the proximal fragment but had not found its way in the distal one.

Lottes et al (1952), Zuckman and Maurer (1969) and Hamza et al (1971) did not ream the medullary canal for fear of geopardising the blood supply. Alms (1962) reamed the medullary canal as a routine before seating nail hence in his series in most of the cases 11 mm diameter nail was accepted. We did not ream the medullary canal so in eight cases (57 percent) nine mm diameter nail was passed while in five cases (29 percent) 10 mm diameter nail was introduced.

In our study of 14 cases two cases (14 percent) had failed closed reduction as in one case the fibula was intact and because of pre-existing partial stability of the limb it was difficult to know clinically whether the guide wire and the nail were correctly placed. Post-operative X-ray revealed the nail lying in the soft tissue. However after seven days, the nail was extracted and closed reduction was tried. But intact fibula continued causing problem in the assessment of guide wire passing into the distal fragment. Eventually open nailing had to be done in this case.

In another case the closed reduction was not achieved and we had to open the fracture site and to our surprise we found that one of the comminuted fragment was overlying the proximal end of distal fragment which was not allowing the guide wire to pass through the fracture site.

In one case(seven percent) the nail left the guide wire at the fracture site and got incarcerated in the cortex of the distal fragment. In this case the guide wire was of smaller diameter and the open part of the Kuntscher nail left the guide wire while the nail was passing through the fracture site. However we did not try to take out the nail as the reduction achieved was acceptable and the patient had comminuted fragments.

In two (14 percent) of our cases distraction at the fracture site occurred after nailing. Retrospectively this could be attributed to oversized nail- diameter wise.

In one case we made the patient to walk without external splintage four days after the surgery and in doing so the distraction was corrected. The other case had significant unicortical comminuted fragment. This precluded early weight bearing but after ten days when stitches were removed under intravenous effect of pentothal sodium firm punches were given over the heel with counter pressure given by the assistant over the knee. The check X-ray showed good appesition of the fragments.

Operative time for successful closed nailing ranged from 20 minutes to a maximum of 50 minutes at an average of 35 minutes. The maximum time of 50 minutes was taken in one case in which nailing was done after an interval of 21 days of injury. In this case we had some problem in breaking the soft callus which had formed and was posing problem in reducing the fracture. The time of 35 minutes on an average is much less than the time taken for any surgery in which open reduction and internal fixation is done hence closed nailing has an advantage of having shorter time of exposure to the surgical trauma. Uptill now no worker has reported the time taken for closed nailing of tibia.

Average hospital stay in the series of Lottes et al (1952) was 1.2 months. Whereas it was three to four weeks in the series of Hamza et al (1971). In our series 58 per cent of cases had an hospital stay of two weeks. Two groups of three cases each had hospital stay of three and four weeks respectively. Increased period of hospital

-isation in these cases was because we gave time for blisters or punctured wound to heal. In a few cases the patient had to face surgical trauma twice because of some per-operative complication. But with increase in our experience the hospital stay of the patients decreased significantly.

Lottes (1954) reported an incidence of 3.3percent deaths occurring within a week of operation, 2.1 percent deep infection and 2.1 percent non union in a series of 254 patients. Smith studied 219 fractures of tibial shaft treated by open reduction and internal fixation and found delayed union occurring in 48 percent and infection in 20 percent. Burwell (1971) reported that 181 fractures of the tibia treated with open reduction and internal fixation using Burns or venable plates had a non union rate of 4.4 percent, an infection rate of 6.6 percent. Berkin and Marshal (1972) fixed three sided plates in 92 tibial fractures which resulted in 3 deaths, 6 infection and eleven delayed union. We did not come across any of these complications even in a single case.

Lottes et al (1952) recorded an angular deformity (three degree or more) in 5.7 percent cases and a shortening (six mm or more) in 1.9 percent cases. They had no case of rotational deformity. Weissman and Herold(1966) treated conservatively and found shortening amounting to 3", 2", 1½" and 1" respectively in four out of 150 cases. Sarmiento (1970) treated 135 cases of fracture shaft

tibia by a functional below knee brace and found an average shortening of about 5.4 mm with no rotational deformity.seen. Dehne et al (1961) reported average shortening of 0.9 cm. Nicoll (1964) reported shortening of more than 2 cm in 2.5 percent of his cases treated by conservative methods. In the present sereis we had no case who had angulation, rotational deformity or shortening.

Nicoll (1964) reported ankle stiffness long after union had occurred in 25 percent of his cases. Weissman et al (1966) observed temporary limitation of movements in the knee and ankle in most of the patients during the first few months after plaster was removed. Joseph (1974) found frequent possibilities of knee and ankle stiffness with a bove knee cast. Emerson and Grabias(183) followed up tibial fractures immobilised with bilateral frames and found that the most frequent complaint was ankle and foot stiffness.

One out of the twelve successful close nailing had limitation of dorsiflexion of ankle joint one and half months after the plaster was removed which gradually recovered by the last follow up. Rest of the patients did not have any limitation of ankle or knee stiffness because while tapping down the nail we threaded on the guide wire another Kuntscher nail of similar diameter as the one being introduced. This greatly facilitated the

seating of nail without trouble. It was because of this improvisation that we were able to sink the upper end of the nail a few millimeters in the tibial plateau without inflicting any soft tissue and bony trauma which went a long way in restoring full range of knee extension post-operatively.

In the present study soon after closed nailing long leg dorsal slab was given. Suitable patients were allowed to walk in the slab a few days after surgery with the help of walker or stick. Initially we hesitated in making them walk early in post-operative period. As we grew in experience and confidence we abondoned over-cautious approach in early ambulation of patients in selected cases. Patients with oblique/spiral fracture and with significant comminution were not allowed to walk until good bridging callus had formed. In all, four cases underwent assisted protected weight bearing at an average of 3.2 weeks. Out of these there were two patients who were ambulant within four days of nailing. unassisted protected weight bearing was started at an average of 5.9 weeks.

Unprotected assisted weight bearing was started at an average of 10.4 weeks whereas unprotected unassisted weight bearing was started at an average of 11.7 weeks which is much earlier than in the series of Lottes et al (1952) and Lottes (1954). Lottes et al (1952) allowed full weight bearing in cast at an average of 1.5 months and unprotected unassisted weight bearing was resumed

on an average five months after injury.

Due to the presence of nail in the medullary canal it was difficult to judge the progress of union clinically as the stability at the fracture site was achieved soon after successful nailing was done. Criteria of absence of pain at the fracture site, good muscle tone and resumption of unassisted weight bearing were certain features to judge the progress of union. Radiologically start of formation of bridging callus and partial obliteration of fracture line were other criteria to consider the rate of union.

In our study average period of start of bridging callus formation and partial obliteration of fracture line were three weeks and six weeks respectively. Absence of pain at the fracture site was reported to be four weeks on an average. Unprotected assisted and unassisted (full weight bearing) was 10.4 weeks and 11.7 weeks respectively. In patients where early weight bearing was started resulted into minimal periosteal callus and early obliteration of fracture site.

Osker Lindon reported average healing time as 22.3 weeks in patients treated conservatively. Robert Funstein (1945) reported average healing time to be 11.2 weeks for clinical union and 30.4 weeks for radiological union. Average time of union of fracture was 16 weeks according to the study done by Nicoll (1964) in his survey of 705 cases treated conservatively.

Karlstrom and Olerud (1975) treated tibial fracture with stable external frame fixator. The average time for full weight bearing without external support was 7.9 months. Dehne (1961) treated fracture tibia by immobilisation in a near skin tight cast with knee in full extension and in these cases average healing and mobilisation was within four to six months.

Vander Linden and Larsen (1979) reported average time of healing in fractures treated by plate and screw as 12 weeks as compared to conservative treatment where the healing time was found to be 17 weeks.

Out of 12 patients of successful closed nailing ten were working men who returned to their work at an average interval of 18 weeks. The early return to work could be attributed to early weight bearing, restoration of joint movements and consequently, also, to early fracture union.

On the other hand conservative method of above knee cast immobilisation, not only prevents early ambulation but also delays return to work. Michael Alms (1962) found an average period of 11 weeks and 22 weeks in patients treated by closed nailing and above knee plaster cast respectively. Slatis (1967) noted that 90 percent of his cases of fracture leg treated by long leg case could resume work by 12 months.

Follow up varied from 52 weeks to seven weeks. No case was lost to follow up. Patients reported faithfully whenever called to the hospital.

Out of 14 cases twelve underwent successful closed nailing. No post operative complications was found in any patient. Suitable patients were kept for early ambulation depending upon the type and fixity of the nail. All except one patient had loss of dorsiflexion at the ankle joint. Excellent results were found in 92 percent whereas good in eight percent of our clinical study.

The technique of closed nailing which had been done by the workers before had been simplified by us, as in this no costly instruments or apparatus were used and we could get 100 percent healing with good alignment of fragments, absence of infection, early ambulation and rapid return to work. We believe that due to the simplicity of the technique it can be brought into practice even at a small centre by a person with some experience related to the subject mentioned above.

CONCLUSION

C O N C L U S I O N

The present study of"Closed Intramedullary Nailing in the treatment of fresh simple fracture of shaft of tibia" was conducted in the department of Orthopaedics, M.L.B. Medical College and associated hospitals, Jhansi. A total number of 14 cases were taken in this study. The results were evaluated and compared with the results of other methods of treatment of fracture tibia.

The closed nailing for fracture tibia has certain outstanding advantages such as :

1. The technique is easy, safe and well acceptable by the patients without the possible complications of open reduction and conventional above knee cast method.
2. The technique does not require highly sophisticated theatres and equipments, so suitable in countries like ours where facilities are lacking in rural areas.
3. The fracture haematoma is not drained.
4. Cancellous bone from within the medullary canal is driven into fracture haematoma.
5. Periosteal supply is not further disrupted.
6. Infection is low or practically nil.
7. With rigid fixation early weight bearing can safely be advocated without fear of loss of reduction, shortening, angulation or rotation.

On the basis of present study the recovery of normal function and union with good results in over whelming majority of cases indicate that it is a good method to practice even at smaller centres for the treatment of fracture shaft tibia in the selected patients who have passed the stage of skeletal maturity.

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